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A Digital Tool to Promote Alcohol and Drug Use Screening, Brief Intervention, and Referral to Treatment Skill Translation: A Mobile App Development and Randomized Controlled Trial Protocol

Derek D Satre[1,2*], PhD; Khanh Ly[3*], BS; Maria Wamsley[3*], MD; Alexa Curtis[4*], PhD; Jason Satterfield[3*], PhD

[1]Weill Institute for Neurosciences, Department of Psychiatry, University of California, San Francisco, CA, United States

[2]Kaiser Permanente Northern California, Division of Research, Oakland, CA, United States

[3]Division of General Internal Medicine, University of California, San Francisco, CA, United States

[4]School of Nursing and Health Professions, University of San Francisco, San Francisco, CA, United States

[*]all authors contributed equally

Corresponding Author:
Derek D Satre, PhD
Weill Institute for Neurosciences
Department of Psychiatry
University of California
401 Parnassus Avenue, Box 0984
San Francisco, CA, 94143
United States
Phone: 1 415 476 7382
Fax: 1 415 502 2661
Email: Derek.Satre@ucsf.edu

Abstract

Background: Translation of knowledge and skills from classroom settings to clinical practice is a major challenge in healthcare training, especially for behavioral interventions. For example, screening, brief intervention, and referral to treatment (SBIRT) is a highly-promoted approach to identifying and treating individuals at risk for alcohol or drug problems, yet effective, routine use of SBIRT has lagged.

Objective: The objective of this paper is to describe the development, pilot testing, and trial protocol of a mobile app based on the theory of planned behavior (TPB) to promote SBIRT skill translation and application.

Methods: Intended for use after classroom training occurs, the mobile app has three primary functions designed to increase behavioral intent to deliver SBIRT: (1) review skills (ie, address knowledge and beliefs about SBIRT), (2) apply skills with patients (ie, build confidence and perceived behavioral control), and (3) report performance data (ie, increase accountability and social norms and/or influence). The app includes depression and anxiety screening tools due to high comorbidity with substance use. A randomized controlled trial (RCT) is in progress among health and social service learners (N=200) recruited from 3 universities and 6 different training programs in nursing, social work, internal medicine, psychiatry, and psychology. Participants are randomized to SBIRT classroom instruction alone or classroom instruction plus app access prior to beginning their field placement rotations. TPB-based data are collected via Qualtrics or via the mobile app pre-post and SBIRT utilization, weekly for 10 weeks. Key outcomes include the frequency of and self-reported confidence in delivery of SBIRT.

Results: Beta testing with advanced practice nursing students (N=22) indicated that the app and its associated assessment tools were acceptable and useful. The system usability scale (SUS) mean was 65.8 (n=19), which indicated that the SBIRT app was acceptable but could benefit from improvement. Indeed, modifications were implemented prior to starting the trial. Enrollment of trial participants began in September 2016. Results are expected by December 2017.

Conclusions: This report describes the process of TPB-based app development and testing, and the protocol for a RCT to determine the effectiveness of the app in enhancing skill translation. If effective, this approach could improve SBIRT implementation, fidelity, and clinical outcomes.

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KEYWORDS

SBIRT; mobile app; digital health; training, implementation; alcohol; drug; depression; anxiety

Introduction

The transition from learning clinical skills to sustained changes in health provider behavior is a known problem. Even when evidence-based treatments are available and implementation decisions have been made, workforce development and sustained intervention delivery present formidable challenges [1]. For example, maintaining fidelity to evidence-based treatments (eg, cognitive behavioral therapy [2]), often requires strategies to support ongoing learning such as supervision and coaching [3]. Providers must learn the new skills, practice the skills, build confidence (in themselves and the intervention), and be able to change past practice norms all within an environment that supports such changes. However, these personnel-intensive strategies can be costly and time-consuming, and have limited reach due to resource constraints. Yet with effective strategies to support skill translation [4,5], behavioral healthcare providers can effectively deliver the interventions they are trained to use. Thus, a major challenge for the implementation of evidence-based behavioral practices concerns how to deliver cost-effective support for skill translation in healthcare.

Screening, brief intervention, and referral to treatment (SBIRT) for unhealthy alcohol and drug use is an important example of a widely-trained skill that has fallen short in translation [6]. SBIRT is designed to reach individuals in health or social service settings who use substances at a range of levels, including those who may not yet meet criteria for alcohol or drug use disorders. Components include screening for hazardous drinking and drug use and related problems, delivering brief motivational interviewing-based interventions for patients at low to moderate risk, and providing referrals to addiction specialty care for those with significant problems [7]. Available evidence supports the effectiveness of screening and brief intervention in addressing hazardous drinking within primary care [8-10], although evidence for effectiveness in reducing drug use is weak and trials have been mixed [11-14]. Based on the strength of this literature, national practice guidelines for SBIRT integration into primary care and other health and social service settings have been developed [15,16].

In spite of these practice recommendations and a proliferation of SBIRT training programs, optimal skill translation to direct clinical care remains unrealized. Trainees often demonstrate classroom skill proficiency yet fail to use SBIRT in subsequent clinical placements. Commonly cited barriers to translation include provider attitudes about substance use interventions, problems with knowledge recall at the point-of-care, lack of confidence, inadequate knowledge of referral resources, as well as structural barriers in clinical settings such as limited time and competing medical demands, especially in primary care [17-19]. Studies of SBIRT skill translation and implementation have found a decrease in post-training SBIRT delivery rates over time [20,21], variability in delivery rates across health disciplines [22,23], and low fidelity to screening questions [24]. Fewer than one in six Americans report being asked about or discussing their drinking with a health professional [25], and screening is rarely conducted in US primary care settings [26] outside the Veteran's Affairs Health System [27]. Similarly, a minority of patients in mental health settings report that providers advise them to reduce hazardous drinking or drug use [28], and a recent meta-analysis demonstrated that fidelity to motivational interviewing by clinicians is often poor [29]. These findings highlight the importance of improving skill translation in real-world health and social service settings.

Digital learning tools have been incorporated into some SBIRT training programs but have not been effectively integrated with clinical care. For example, online training modules sometimes supplement didactic presentations and demonstrations, role play with feedback, and patient encounters [30-32]. With some variability, these digital health training components have been rated as relevant and useful by trainees. Outcome studies have found that such training resulted in increased confidence in SBIRT delivery and more positive attitudes towards patients who use alcohol [33]. Yet digital tools such as online learning models have not supported skill translation over time. To our knowledge, the one SBIRT mobile app that is currently available does not incorporate background materials targeted towards trainees (eg, review of prevalence of substance use and evidence for SBIRT efficacy), nor does it include detailed support in conducting screening, delivering interventions, and treatment referral resources [34]. If designed with skill translation in mind, a point-of-care mobile app with this additional content could help providers apply newly learned SBIRT skills [1].

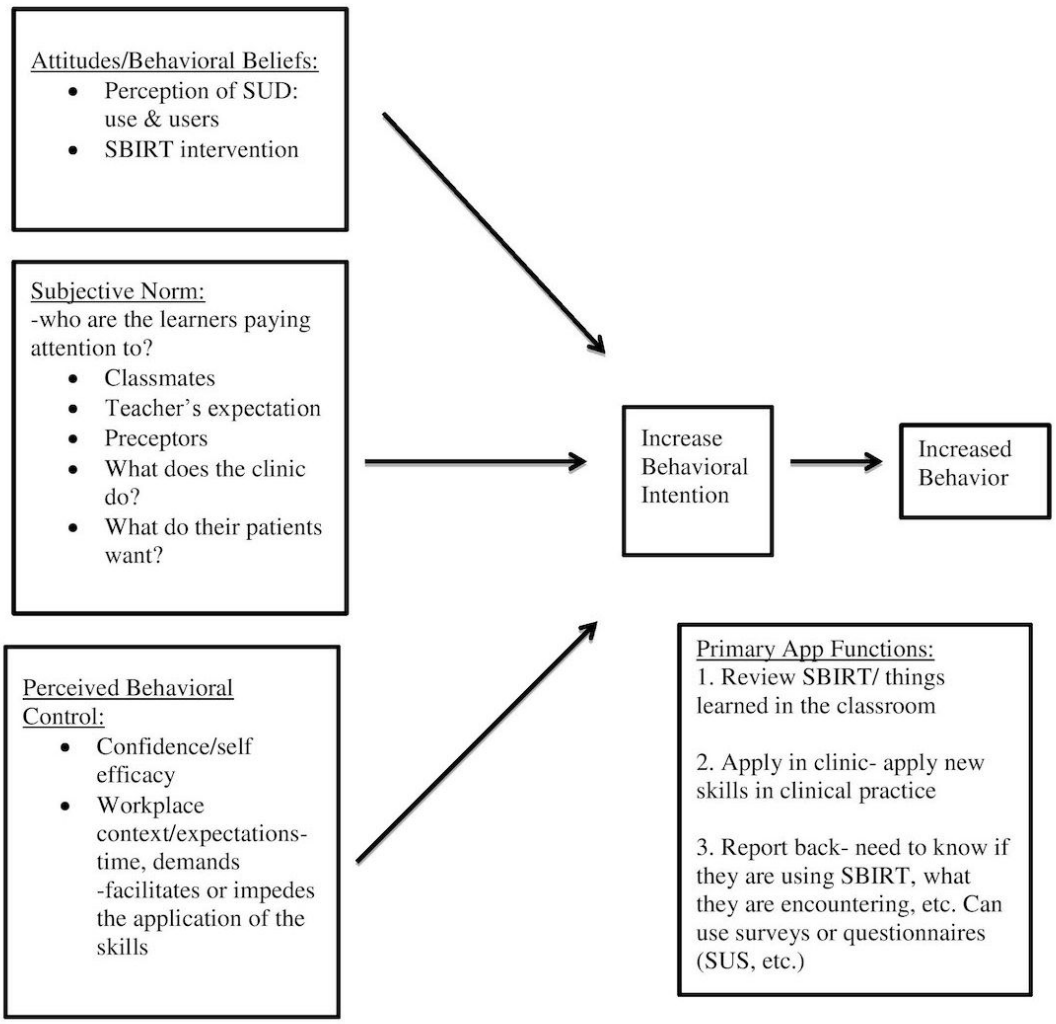
In other health delivery contexts, mobile apps are gaining acceptance and appear to enhance training. Bullock et al (2015) found that providing a mobile app containing the Dr Companion software with 5 key medical textbooks (the iDoc app) to newly qualified doctors increased access to reference materials and was effective in supporting learning and practice [35]. The use of mobile technology, including medical apps in nursing education, has demonstrated success in improving learning outcomes and learner confidence [36]. Tablet-based patient self-administered alcohol and drug screening [37,38] and intervention [39] can increase efficiency in healthcare settings. Yet prior studies have not examined how mobile apps may enhance SBIRT training and skill translation.

Theoretical models identifying barriers and facilitators regarding learning and skill translation may help guide the development of intervention strategies to enhance skill transfer and implementation. On the level of individual provider (or learner) behavior, the theory of planned behavior (TPB) provides a well-validated, conceptual model that identifies both internal and external key factors that could influence SBIRT skill translation [40]. In the TPB model, behavioral intent (to perform the behavior of interest) is determined by attitudes and/or beliefs about the behavior, perceived social norms, and perceived behavioral control. The TPB is contextualized for SBIRT skill translation in Figure 1, allowing us to assess learners on each of these variables and to provide matched interventions as needed to promote SBIRT usage. For example, we provide

information on the extent of substance use and related problems, and SBIRT efficacy to shape attitudes regarding the value of screening and treatment. We provide information on standards of care (eg, that SBIRT has been recommended by the US Preventive Task Force and many health professional bodies) to influence perceived social norms. Moreover, we provide tools to support practicing SBIRT to positively impact both attitudes and perceived behavioral control such as trainees' confidence in successfully performing SBIRT and integrating it into clinical care.

The aim of this paper is to describe the process of TPB-based mobile alcohol and drug SBIRT app development, beta testing, and protocol for a randomized controlled trial (RCT) comparing health professional learners with access to the app (intervention arm) to learners without access to the app (control arm). We hypothesize that participants in the intervention arm will be more likely to deliver SBIRT in clinical placements than those in the control arm and will be more likely to report intention to deliver SBIRT in the future. We also hypothesize that intervention participants will report more positive beliefs about SBIRT, greater knowledge, and greater perceived control over SBIRT delivery in clinic.

Figure 1. Theory of planned behavior as applied to screening, brief intervention, and referral to treatment (SBIRT) skill translation. Model adapted from Ajzen (1991). SUD: substance use disorder; SUS: system usability scale.



Methods

App Development

An interprofessional team worked to develop the TPB-based app. The team was comprised of faculty members with prior research expertise in SBIRT training and implementation and included two clinical psychologists with doctorate degrees, an internal medicine physician, an advanced practice nurse with a doctorate degree, and an experienced project manager. Existing mobile apps were identified to determine needs in the field and to learn about components often emphasized in enhancing behavior change, for example, mobile apps for SBIRT [34], Change Talk for Childhood Obesity [41], and Epocrates [42]. Digital product design principles were reviewed including the creation of a product vision and end goal, character sketches of potential users ("personas"), features of currently available

products, and emerging mobile app tools that simplify the user interface and promote app usage [43]. The app's purpose and vision evolved based on faculty and learner responses to initial designs. As follow-up to a needs assessment questionnaire, faculty members from different training programs were asked about the potential utility of a mobile app to increase learners' use of SBIRT. Learners identified specific features and content they wanted while using the app during clinic placements. For example, learners wanted point-of-care screening tools and SBIRT frequency of use measures integrated directly into the app.

Based on this initial feedback, the app was designed as a tool for learners to use at their clinic sites that could function as both an SBIRT information resource and as a tool to assist in skills practice and implementation. Content was designed to primarily address alcohol and drug use, but screeners for depression and anxiety, which commonly co-occur with problematic substance use, were added to broaden the scope of the app and to increase its perceived value to both learners and preceptors. A key design principle was to ensure the app fit within the clinical environment and did not disrupt other training or patient care activities. Because of data security concerns and the range of service settings and medical record systems in which trainees could use SBIRT, the app was not designed to connect with local electronic health records and does not record any protected health information. Given the expense and complexity of integrating screening into healthcare records, with which the faculty had prior experience (eg, integration of alcohol screening into electronic health records in Kaiser Permanente Northern California [22]), and the fact that not all learners are placed in settings that have electronic records, we anticipated that keeping the app separate from patient record systems would maximize learner flexibility across various clinical placements and assuage concerns about loss of patient privacy.

Flow diagrams and wireframes (page schematics and screenshots) were drafted to correspond to the key components of the app. Open Health Network app developers [44] were selected as a development partner based on their prior experience in developing mobile apps for healthcare. The wireframes were given to the developers, who provided an initial alpha version. Team members tested the alpha version individually and worked with the developers to continue refining the flow and content for subsequent beta testing.

Beta Testing

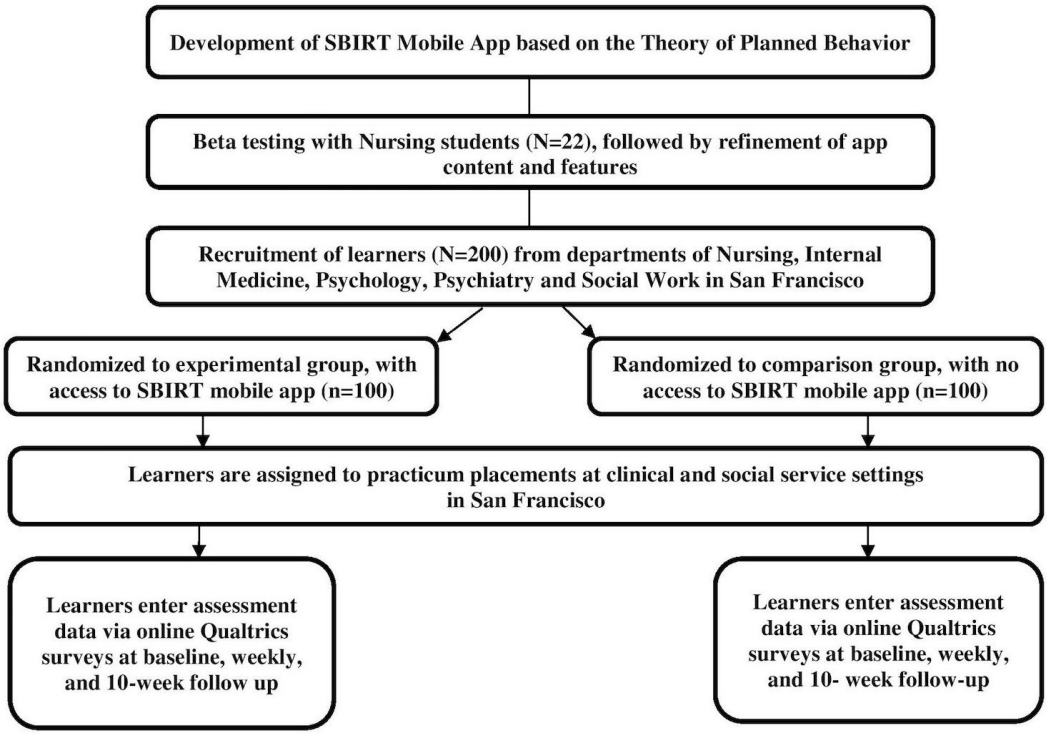
Once the final beta version of the app was developed, our team chose a small cohort of nurse practitioner learners (N=22) at the University of San Francisco to beta test the app for 3 months. Our testers included learners in an advanced practice nursing training program who were enrolled in a clinic placement. Learners completed the questionnaires and processes to be used in the larger RCT. Full TPB-based surveys (see "Pre/Post Assessment Questions") were repeated at the end of the beta-testing period, followed by a debrief focus group. The team tested and refined the app prior to starting the controlled trial. Beta testing results are described below.

Randomized Controlled Trial

Study Design

The study is a RCT of an SBIRT mobile app to facilitate skill translation from classroom to clinical placements among 200 graduate and post-graduate learners (Figure 2). Following SBIRT instruction, participants are enrolled and randomized to the experimental (use of the app) or control (no access to the app) condition. All participants complete self-report measures over the study duration (10 weeks). The trial runs from fall 2016 through spring 2017.

Figure 2. Overall study design for the development and testing of an alcohol and drug screening, brief intervention, and referral to treatment (SBIRT) mobile app to enhance skill translation. Figure adapted from the CONSORT Group.



Setting

The trial is being carried out at 3 sites, among 6 training programs: San Francisco State University (Social Work and Nursing), University of California, San Francisco (Internal Medicine and Psychiatry), and University of San Francisco (Nursing and Psychology). Institutional review boards at the 3 sites approved all study procedures. The study is not registered with ClinicalTrials.gov because the design does not include a collection of clinical data or patient-level outcomes.

Participants

Study participants (trainees, N=200) are adult health professional learners in one of the designated training programs. Participants must have had prior classroom or online training in SBIRT within the past year and may not have previously used an SBIRT app. For learners who have not yet completed classroom-based SBIRT instruction, they are required to complete the following 3 online training modules developed by the research team: (1) Introduction to SBIRT, (2) Screening, and (3) Brief Intervention. The learner must be enrolled in a field placement and is required to have a mobile device to be in the study (Android or iOS). Field placements include a range of private and public healthcare and social service agencies in the San Francisco Bay Area.

Recruitment and Randomization

Project faculty identified SBIRT educators at the participating training programs and received permission to recruit students. Students are recruited during scheduled classroom time using a detailed information sheet that specifies expectations, timing, and types of data to be collected. Absent learners are invited to participate via email recruitment. Participants provide informed consent to participate either live in classroom settings or via email.

Standard randomization procedures used in behavioral intervention studies are followed [45] using a variable block size with a 1:1 allocation to the intervention or control arm design. These procedures are carried out by the study project manager. Learners are assigned an identification number that is used for the randomization. A Web-based randomization tool is used to generate group assignments. Randomization is stratified by training program in order to have an even distribution of learners in the intervention and control groups from each program.

Intervention Arm

Participants in the intervention group are asked to download the app, use it in their clinical rotations (either on their personal mobile phones or tablets), and complete periodic questionnaires via a Qualtrics link. The learners have the opportunity to use the app as much as they need to review SBIRT, receive guidance on structured steps in SBIRT delivery, and receive tailored recommendations on what they can do to improve. We included modest incentives for app use to maximize our ability to measure the potential effects of app use in the trial.

Control Arm

Participants in the control group do not download or use the mobile app in their practicum placements but have access to usual teaching materials and supervisors. Control participants complete periodic questionnaires via a Qualtrics link throughout

the study period. Upon completion of the study, they are invited to download and use the app at their discretion.

Data Collection

At baseline, all participants answer a TPB-based questionnaire via Qualtrics (control) or directly on the app (intervention). At the end of each week, all participants are asked to respond to a brief Qualtrics survey about how often they used SBIRT either by text message (short message service, SMS) or by email. Upon completion of their clinical rotation, all learners are asked to repeat the original TPB-based questionnaire and to provide general feedback about either the app usage (intervention) or their general satisfaction with SBIRT (control).

Incentives

Learners in both groups receive incentives for participating. The incentives are intended to enhance motivation of the learners to use the mobile app and complete study questionnaires. The learners receive Amazon gift cards throughout the study valued at US $20 at baseline, $2.50 for each completed SBIRT usage questionnaire, and $20 at the end of the study for answering the final questionnaire. Maximum payment is US $65 plus participation in a US $50 gift card lottery based on the completion of the SBIRT usage questionnaires.

Measures

Data on participants include demographic characteristics, training institution and level of training, type of patients served in clinical placement, and pre-post TPB-based questions to capture the TPB constructs described above (Table 1).

Table 1. Measures used in the screening, brief intervention, and referral to treatment (SBIRT) mobile app randomized controlled trial (RCT).

Source	Data elements	Instrument	Timeline
All participants	Demographic characteristics	Self-report	Baseline
All participants	Type of clinical placement and population served	Self-report	Baseline
All participants	SBIRT[a] attitudes, norms, behavioral control	TPB[b]-based survey (22 items)	Baseline and 10 weeks
All participants	Delivery of SBIRT components during clinical placement	Survey	Weekly
All participants	Satisfaction with the app and usability	SUS[c] (10 items)	10 weeks
Control participants	Satisfaction with SBIRT	Survey (10 items)	10 weeks

[a]SBIRT: screening, brief intervention, and referral to treatment.

[b]TPB: theory of planned behavior.

[c]SUS: system usability scale.

Pre-Post Assessment Questions

The team developed a 22-item questionnaire based on the TPB model. Likert-scaled items assess attitudes and beliefs including importance and efficacy of SBIRT, perceived patient willingness to participate in SBIRT, substance use epidemiology and clinical significance, and subjective norms and perceived behavioral control in the clinic setting. Three items assess confidence in the respondents' ability to screen for alcohol or drug use problems, deliver a brief intervention, and to make referrals. One item assesses intent to perform SBIRT "whenever possible in my clinical/field placement." All participants complete this questionnaire at baseline and again at 10 weeks. For intervention participants, baseline TPB responses are used to tailor their app experience by making specific recommendations of what the learner might need to review within the app's library.

The system usability scale (SUS) [46] is a 10-item Likert scale instrument developed to measure aspects of usability including system complexity and need for support and training. It yields a single score ranging from 0 to 100. Intervention group participants complete this measure at follow-up.

Satisfaction

We developed a 10-item Likert scale questionnaire to measure the experiences of control group participants, as a counterpart to the SUS. Items include barriers and challenges to SBIRT delivery to determine why some participants might not have used SBIRT in the context of their clinical placement. We included the satisfaction questionnaire for control participants only because we want to ensure they have an equivalent number of questions to the intervention participants, and we were concerned about survey burden with our intervention participants.

Utilization.

At the end of each clinic week, every participant is sent (via email or text) a Qualtrics link asking them to report the total number of patients they have seen in the preceding week. Participants then are asked how many of those patients they screened for alcohol, drug, or tobacco use, how many they did a brief intervention with, and how many they either referred to a specialty substance use treatment clinic or discussed with their field supervisor.

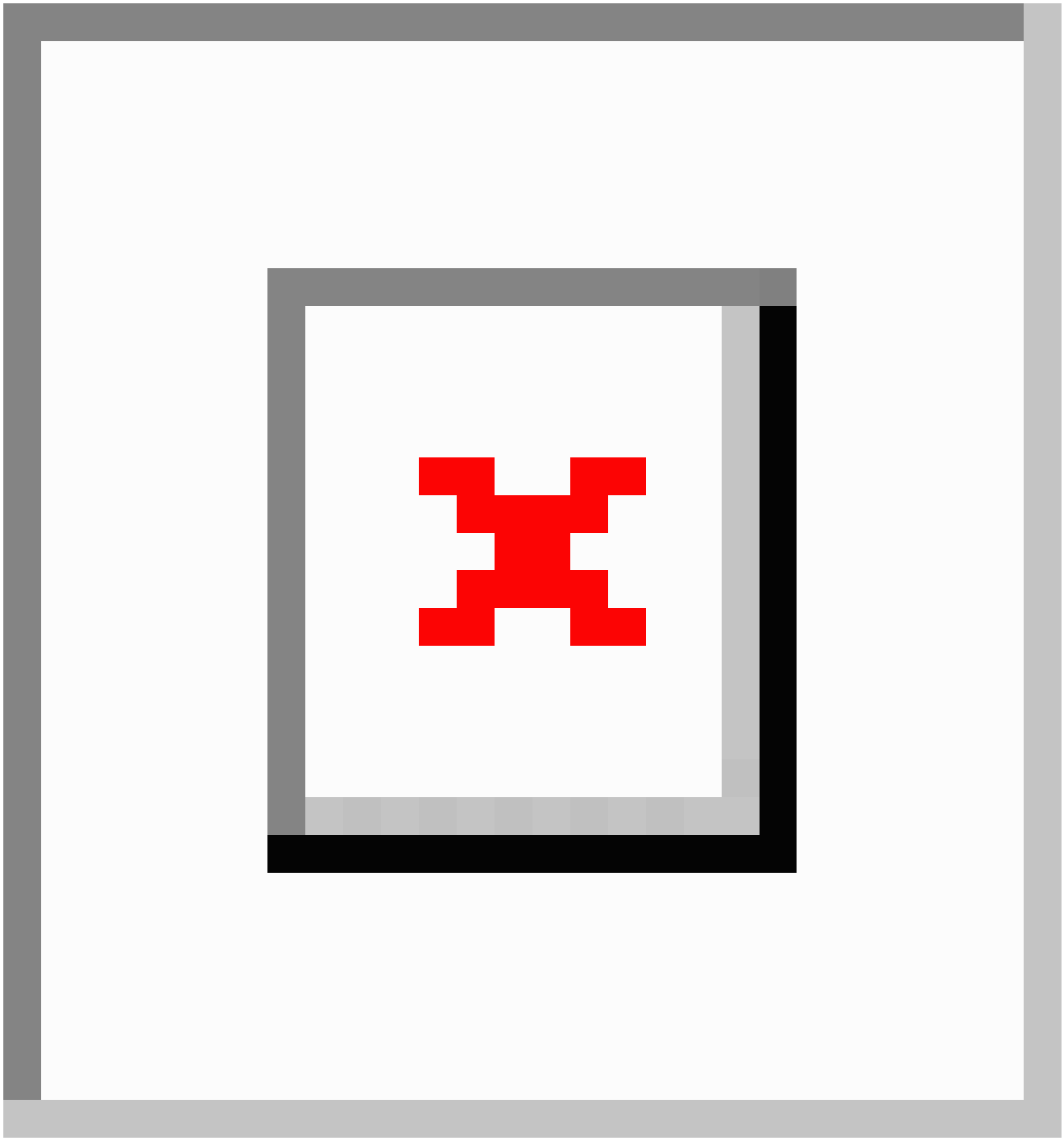
Intervention

Design and Function

The SBIRT app has the following three primary functions to address TPB concepts: (1) Review SBIRT skills (to help change beliefs and attitudes), (2) Apply SBIRT skills in clinic practice (to help impact attitudes, perceived behavioral control), and (3) Report SBIRT use (to report norms, as well as study outcomes). A fourth component, the Tools section, includes additional reference material and links (Figure 3). After downloading the app, intervention learners create an account and complete the

pre-TPB survey. Immediate TPB results are given to the learners along with tailored recommendations on what they should do next. For example, if learners score low on SBIRT knowledge, they are directed to the Review section. A progress checklist in the Tools section reminds them of "homework" they still need to complete. Throughout the study intervention learners are reminded to use the app via the weekly SBIRT usage surveys and periodic text messages promoting app usage.

Figure 3. Screen shot of the screening, brief intervention, and referral to treatment (SBIRT) mobile app home screen.



Review

The Review section includes content taught in the classroom (which is also available to learners online), as well as additional material. Subheadings include "Basics" (eg, epidemiology, drugs of abuse, consequences, defining SBIRT), "Screening" (eg, screening questions, sample scripts, and the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [DSM-5] definition of substance use disorder [47]), "Brief Intervention" (eg, brief advice, motivational interviewing, harm reduction), "Referral to Treatment" (eg, referral processes, pharmacotherapy), and "Key Resources" (eg, case illustrations, video demonstrations, external links to the National Institute on Alcohol Abuse and Alcoholism, and the National Institute on Drug Abuse).

Apply

The Apply section assists learners in using SBIRT while with a patient in clinic placements. This section includes screener instruments, scoring tools, scripts, and step-by-step guidance

for delivering a brief intervention or referring a patient to alcohol or drug treatment. For example, the app allows users to specify what they want to screen (eg, alcohol, drugs, depression, anxiety), tailors those questions by gender and age group (18 to 64 versus 65 and up), includes single-question hazardous drinking and drug use screeners, as well as the Alcohol Use Disorders Identification Test (AUDIT) [48], CRAFFT (CRAFFT is a mnemonic acronym of first letters of key words in six screening questions) [49], and Drug Abuse Screening Test (DAST) [50]. Depression screening using the Patient Health Questionnaire (PHQ-2 and PHQ-9) [51] and anxiety screening using the Generalized Anxiety Disorder (GAD-2 and GAD-7) [52] measures are also included due to high comorbidity with substance use and commonalities in intervention approaches. Other subsections include tips for delivering brief interventions, including brief negotiated interviews/motivational interviewing, and suggestions for making referrals (eg, referral processes, lists of local treatment resources, and national treatment locators).

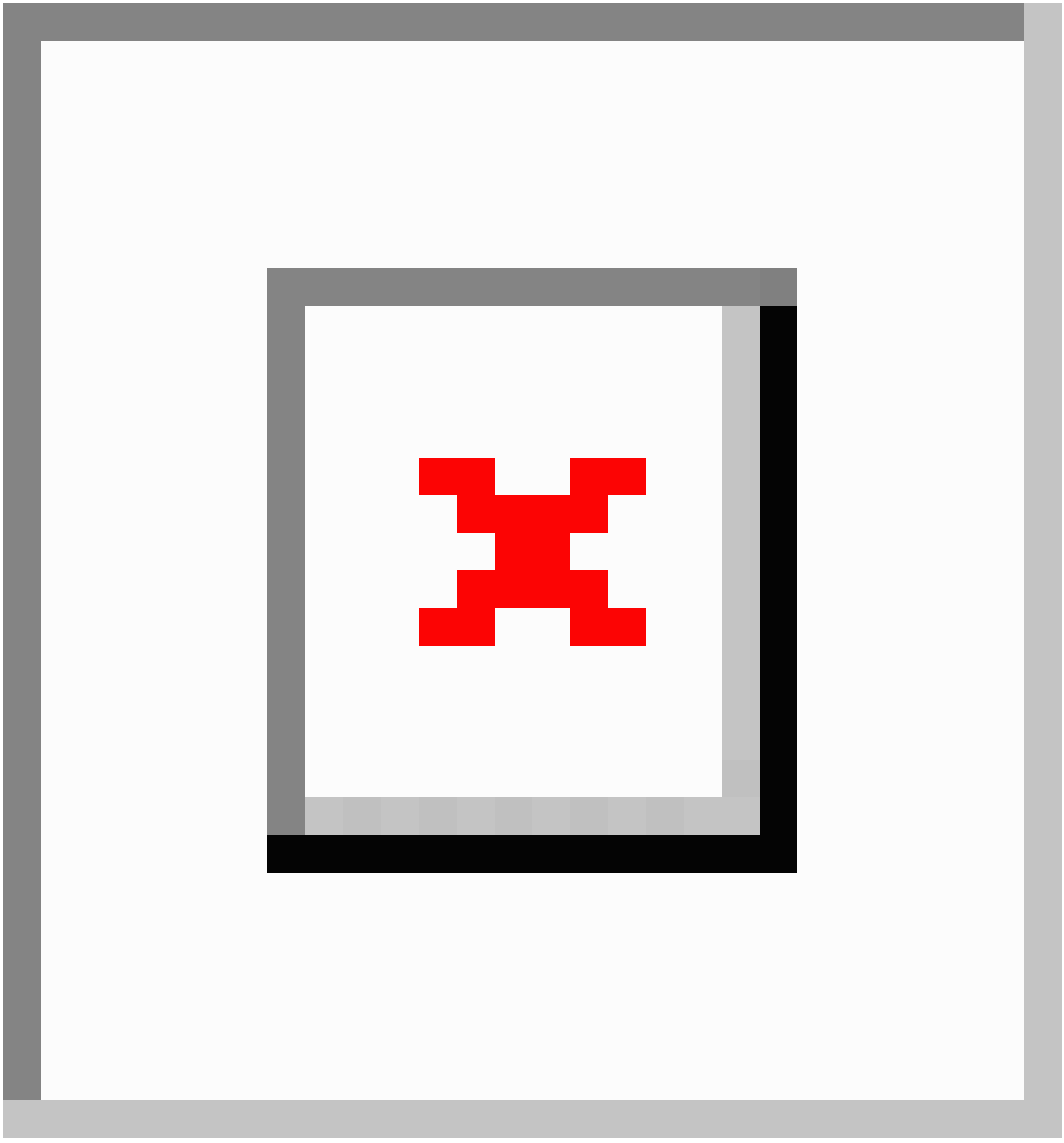
Report

The Report section was originally conceptualized as a library of tools for instructors and clinical preceptors to track and evaluate their learners. We initially included a collection of pre-post surveys and weekly SBIRT usage items that intervention participants would complete. In order to standardize the data collection procedures across control and intervention participants, all weekly SBIRT usage surveys were completed via Qualtrics. Intervention participants still completed the pre-post TPB surveys and final satisfaction surveys on the app. However, instructors do not receive reports regarding use of the app or SBIRT by learners.

Tools

The Tools section includes social networking, feedback and tracking, and gamification or incentive-building tools. Social networking tools include the “social connection” to send message questions to the study team or other app users. The “Progress Checklist” allows learners to check their progress on which pages they have visited and which pages they still need to review. “Technological Support” is included in this section for those who have technical difficulties and can contact the app developers directly for help. “Leaderboard” is a page on which other learners who are using the app are listed, along with a point system indicating frequency of app use. Leaderboard rankings were tied to lottery tickets and bonus incentives (Figure 4).

Figure 4. Screenshots of the Review, Apply, Report, and Tools subsections of the screening, brief intervention, and referral to treatment (SBIRT) mobile app.



Analyses

Analyses will be conducted using SAS (SAS Institute Inc., 2011). Descriptive statistics, including distributions, means, standard deviations, skewness, and kurtosis will be obtained for all variables. Continuous measures will be tested for normality and homogeneity of variance. If the distribution is normal, Likert-scale responses will be analyzed as continuous scores [53]. Chi-square tests, student *t* tests, and analysis of variance (ANOVA) tests will be used to determine inclusion in multivariate regression models. Bivariate analyses will examine rate of SBIRT delivery in the two arms and comparison of TPB-based measures (eg, beliefs about SBIRT, social norms and influence, and perceived behavioral control). Multivariate analyses (logistic and multiple regression) will examine the impact of these factors on SBIRT delivery.

Results

Beta Testing

Initial results focus on beta testing with student learners from the University of San Francisco School of Nursing. Beta testing was completed in summer 2016. The SUS mean was 65.8 (n=19) which indicates that the SBIRT app is acceptable but needs improvements before rolling out to a larger study sample. Debrief participants reported satisfaction with the Apply and Review sections, which included brief intervention scripts, video

demonstrations, the level of detail included in the "Referral to Treatment" section, and inclusion of the PHQ-9 (because this is often required in clinic settings to screen for depression). Suggestions for improvement focused on ease of sign-on and reducing the need for navigation (eg, by having multiple scale items appear on a single screen). These formative beta test data were used for app improvement in preparation for the RCT.

Randomized Controlled Trial

Enrollment of trial participants began in September 2016 and recruitment is ongoing. Trial results are anticipated to be available in late 2017.

Discussion

Principal Findings

The study team found that the TBP model was a useful framework for SBIRT mobile app development and that beta testers responded positively overall to the content and features of the app. The app was developed as a tool to promote translation of substance use screening and intervention skills from classroom to clinical settings. Our intent was to assist in workforce development and promote the broader use of evidence-based interventions to reduce alcohol and drug problems among patients in healthcare and social service settings. We used an app to support SBIRT skill translation, embedded in a TPB-based approach to learning, in order to inform the field regarding how mobile app technology may be used to reinforce pedagogy, improve implementation, and enhance patient care. The app, "UCSF OHN SBIRT App," has been positively reviewed online [54] and is now publicly available for free downloading (iOS only) via the iTunes store [55] (Figure 5). The RCT in process will determine whether the app has a significant impact on SBIRT skill translation, including rates of SBIRT delivery, learner attitudes, and intent to deliver SBIRT.

Based on the evidence and the need for intervention tools usable across settings to reduce alcohol- and drug-related problems, SBIRT instruction in both graduate training programs and continuing education settings for healthcare professionals has been spearheaded by the US Substance Abuse and Mental Health Services Administration, and training opportunities have expanded rapidly over the past 10 years. If efficacy is demonstrated, the mobile app developed by the study team may serve as a useful tool to improve training for healthcare providers and enhance patient care.

This theory-based mobile app serves as a reference guide, a clinical tool, and a data collection instrument. Learners are expected to complete the initial TPB assessment questions before starting their clinical rotations and are then asked to use the app as often as possible during the course of providing direct care. The reporting function frequency of completion is dependent on the structure of the clinical rotation and the needs of the training program and/or preceptors. Although learners' use of SBIRT is ultimately limited by what their clinical rotation and preceptor allows, this tool may increase the likelihood of effective SBIRT delivery in healthcare and social service settings. This initial presentation describes our mobile app development process, beta testing, and randomized trial methods, which aim to determine the potential impact of this digital tool.

Figure 5. Icon of the screening, brief intervention, and referral to treatment (SBIRT) mobile app.

Limitations

The RCT is conducted in the context of graduate training in the schools in nursing, psychology, social work, and medicine, and may not generalize to other types of professional training or to providers learning SBIRT in the context of continuing education. A limitation of the trial methodology that could impact our study results is the inclusion of incentives within the intervention arm for participants to use the app, which likely would not exist in actual clinical settings. In addition, some clinical settings and supervisors may not be support the use of SBIRT, and this could impact a learner's ability to use the app. Although use of mobile devices is becoming widespread, limitations in access to technology could impact the reach of this tool [36,56]. The app was not designed to integrate responses to screening measures to electronic health records, which could limit its applicability in some clinical settings. Similarly, issues such as adherence to app usage, appropriate use of technology in the workplace, etiquette, and distraction need to be addressed in future studies [57] to effectively integrate mobile apps into health and social service settings.

Conclusions

In behavioral health, mobile apps have primarily been directed toward patients, including alcohol and drug use reduction [58-61], smoking cessation [62], management of depression [63], and other mental health conditions [64,65]. Our approach is innovative in that it uses a skill translation theory-based intervention to target care providers and improve service delivery for important behavioral health problems. If effective, the mobile app could be scaled-up to reach a wider clinical audience and may be useful in future work on developing models of SBIRT fidelity and broader approaches to improving skill translation.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 5

CONSORT eHealth checklist V1.6.1.

[PDF File (Adobe PDF File), 7MB - resprot_v6i4e55_app1.pdf]

References

1. Abidi L, Oenema A, Nilsen P, Anderson P, van de Mheen D. Strategies to overcome barriers to implementation of alcohol screening and brief intervention in general practice: a Delphi study among healthcare professionals and addiction prevention experts. Prev Sci 2016 Dec;17(6):689-699 [FREE Full text] [doi: 10.1007/s11121-016-0653-4] [Medline: 27167074]
2. Teague GB, Mueser KT, Rapp CA. Advances in fidelity measurement for mental health services research: four measures. Psychiatr Serv 2012 Aug;63(8):765-771 [FREE Full text] [doi: 10.1176/appi.ps.201100430] [Medline: 22854723]
3. Webster-Stratton CH, Reid MJ, Marsenich L. Improving therapist fidelity during implementation of evidence-based practices: Incredible Years program. Psychiatr Serv 2014 Jun 01;65(6):789-795. [doi: 10.1176/appi.ps.201200177] [Medline: 24686513]
4. Goldner EM, Jeffries V, Bilsker D, Jenkins E, Menear M, Petermann L. Knowledge translation in mental health: a scoping review. Healthc Policy 2011 Nov;7(2):83-98 [FREE Full text] [Medline: 23115572]
5. Ravitz P, Wondimagegn D, Pain C, Araya M, Alem A, Baheretibeb Y, et al. Psychotherapy knowledge translation and interpersonal psychotherapy: using best-education practices to transform mental health care in Canada and Ethiopia. Am J Psychother 2014;68(4):463-488. [Medline: 26453347]
6. Reho K, Agley J, DeSalle M, Gassman RA. Are we there yet? A review of screening, brief intervention, and referral to treatment (SBIRT) implementation fidelity tools and proficiency checklists. J Prim Prev 2016 Aug;37(4):377-388. [doi: 10.1007/s10935-016-0431-x] [Medline: 27062499]
7. Babor TF, McRee BG, Kassebaum PA, Grimaldi PL, Ahmed K, Bray J. Screening, brief intervention, and referral to treatment (SBIRT): toward a public health approach to the management of substance abuse. Subst Abus 2007;28(3):7-30. [doi: 10.1300/J465v28n03_03] [Medline: 18077300]
8. Kaner E, Bland M, Cassidy P, Coulton S, Deluca P, Drummond C, et al. Screening and brief interventions for hazardous and harmful alcohol use in primary care: a cluster randomised controlled trial protocol. BMC Public Health 2009 Aug 10;9:287 [FREE Full text] [doi: 10.1186/1471-2458-9-287] [Medline: 19664255]
9. Bertholet N, Daeppen J, Wietlisbach V, Fleming M, Burnand B. Reduction of alcohol consumption by brief alcohol intervention in primary care: systematic review and meta-analysis. Arch Intern Med 2005 May 09;165(9):986-995. [doi: 10.1001/archinte.165.9.986] [Medline: 15883236]

10. O'Donnell A, Anderson P, Newbury-Birch D, Schulte B, Schmidt C, Reimer J, et al. The impact of brief alcohol interventions in primary healthcare: a systematic review of reviews. Alcohol Alcohol 2014;49(1):66-78 [FREE Full text] [doi: 10.1093/alcalc/agt170] [Medline: 24232177]
11. Roy-Byrne P, Bumgardner K, Krupski A, Dunn C, Ries R, Donovan D, et al. Brief intervention for problem drug use in safety-net primary care settings: a randomized clinical trial. JAMA 2014 Aug 06;312(5):492-501 [FREE Full text] [doi: 10.1001/jama.2014.7860] [Medline: 25096689]
12. Saitz R, Palfai TP, Cheng DM, Alford DP, Bernstein JA, Lloyd-Travaglini CA, et al. Screening and brief intervention for drug use in primary care: the ASPIRE randomized clinical trial. JAMA 2014 Aug 06;312(5):502-513 [FREE Full text] [doi: 10.1001/jama.2014.7862] [Medline: 25096690]
13. Aldridge A, Dowd W, Bray J. The relative impact of brief treatment versus brief intervention in primary health-care screening programs for substance use disorders. Addiction 2017 Feb;112 Suppl 2:54-64. [doi: 10.1111/add.13653] [Medline: 28074568]
14. Schwartz RP, Gryczynski J, Mitchell SG, Gonzales A, Moseley A, Peterson TR, et al. Computerized versus in-person brief intervention for drug misuse: a randomized clinical trial. Addiction 2014 Jul;109(7):1091-1098 [FREE Full text] [doi: 10.1111/add.12502] [Medline: 24520906]
15. Moyer VA, Preventive Services Task Force. Screening and behavioral counseling interventions in primary care to reduce alcohol misuse: U.S. preventive services task force recommendation statement. Ann Intern Med 2013 Aug 06;159(3):210-218. [doi: 10.7326/0003-4819-159-3-201308060-00652] [Medline: 23698791]
16. Substance Abuse and Mental Health Services Administration. Technical Assistance Publication Series TAP 33. Rockville, MD: U.S. Department of Health and Human Services; 2013. Systems-level implementation of screening, brief intervention, and referral to treatment URL: http://www.integration.samhsa.gov/sbirt/TAP33.pdf [WebCite Cache ID 6pSHP7kM9]
17. Rahm AK, Boggs JM, Martin C, Price DW, Beck A, Backer TE, et al. Facilitators and barriers to implementing screening, brief intervention, and referral to treatment (SBIRT) in primary care in integrated health care settings. Subst Abus 2015;36(3):281-288. [doi: 10.1080/08897077.2014.951140] [Medline: 25127073]
18. Satre DD, McCance-Katz EF, Moreno-John G, Julian KA, O'Sullivan PS, Satterfield JM. Using needs assessment to develop curricula for screening, brief intervention, and referral to treatment (SBIRT) in academic and community health settings. Subst Abus 2012;33(3):298-302 [FREE Full text] [doi: 10.1080/08897077.2011.640100] [Medline: 22738009]
19. Wamsley MA, Steiger S, Julian KA, Gleason N, O'Sullivan PS, Guy M, et al. Teaching residents screening, brief intervention, and referral to treatment (SBIRT) skills for alcohol use: using chart-stimulated recall to assess curricular impact. Subst Abus 2016;37(3):419-426. [doi: 10.1080/08897077.2015.1127869] [Medline: 26675123]
20. van Beurden I, Anderson P, Akkermans RP, Grol RP, Wensing M, Laurant MG. Involvement of general practitioners in managing alcohol problems: a randomized controlled trial of a tailored improvement programme. Addiction 2012 Sep;107(9):1601-1611. [doi: 10.1111/j.1360-0443.2012.03868.x] [Medline: 22372573]
21. Williams EC, Johnson ML, Lapham GT, Caldeiro RM, Chew L, Fletcher GS, et al. Strategies to implement alcohol screening and brief intervention in primary care settings: a structured literature review. Psychol Addict Behav 2011 Jun;25(2):206-214. [doi: 10.1037/a0022102] [Medline: 21517141]
22. Mertens JR, Chi FW, Weisner CM, Satre DD, Ross TB, Allen S, et al. Physician versus non-physician delivery of alcohol screening, brief intervention and referral to treatment in adult primary care: the ADVISe cluster randomized controlled implementation trial. Addict Sci Clin Pract 2015 Nov 19;10:26 [FREE Full text] [doi: 10.1186/s13722-015-0047-0] [Medline: 26585638]
23. Sterling S, Kline-Simon AH, Satre DD, Jones A, Mertens J, Wong A, et al. Implementation of screening, brief intervention, and referral to treatment for adolescents in pediatric primary care: a cluster randomized trial. JAMA Pediatr 2015 Nov;169(11):e153145. [doi: 10.1001/jamapediatrics.2015.3145] [Medline: 26523821]
24. Bradley KA, Lapham GT, Hawkins EJ, Achtmeyer CE, Williams EC, Thomas RM, et al. Quality concerns with routine alcohol screening in VA clinical settings. J Gen Intern Med 2011 Mar;26(3):299-306. [doi: 10.1007/s11606-010-1509-4] [Medline: 20859699]
25. McKnight-Eily LR, Liu Y, Brewer RD, Kanny D, Lu H, Denny CH, Centers for Disease Control and Prevention (CDC). Vital signs: communication between health professionals and their patients about alcohol use--44 states and the District of Columbia, 2011. MMWR Morb Mortal Wkly Rep 2014 Jan 10;63(1):16-22 [FREE Full text] [Medline: 24402468]
26. Garnick DW, Horgan CM, Merrick EL, Hoyt A. Identification and treatment of mental and substance use conditions: health plans strategies. Med Care 2007 Nov;45(11):1060-1067. [doi: 10.1097/MLR.0b013e31812e01bb] [Medline: 18049346]
27. Bradley KA, Williams EC, Achtmeyer CE, Volpp B, Collins BJ, Kivlahan DR. Implementation of evidence-based alcohol screening in the Veterans Health Administration. Am J Manag Care 2006 Oct;12(10):597-606 [FREE Full text] [Medline: 17026414]
28. Satre DD, Leibowitz AS, Mertens JR, Weisner C. Advising depression patients to reduce alcohol and drug use: factors associated with provider intervention in outpatient psychiatry. Am J Addict 2014;23(6):570-575 [FREE Full text] [doi: 10.1111/j.1521-0391.2014.12140.x] [Medline: 25164533]
29. Hall K, Staiger PK, Simpson A, Best D, Lubman DI. After 30 years of dissemination, have we achieved sustained practice change in motivational interviewing? Addiction 2016 Jul;111(7):1144-1150. [doi: 10.1111/add.13014] [Medline: 26216706]

30. Clemence AJ, Balkoski VI, Schaefer BM, Lee M, Bromley N, Maisonneuve IM, et al. Multispecialty screening, brief intervention, and referral to treatment (SBIRT) training in an academic medical center: resident training experience across specialties. Subst Abus 2016;37(2):356-363. [doi: 10.1080/08897077.2015.1082953] [Medline: 26308425]
31. Kalu N, Cain G, McLaurin-Jones T, Scott D, Kwagyan J, Fassassi C, et al. Impact of a multicomponent screening, brief intervention, and referral to treatment (SBIRT) training curriculum on a medical residency program. Subst Abus 2016;37(1):242-247 [FREE Full text] [doi: 10.1080/08897077.2015.1035841] [Medline: 25961140]
32. Pringle JL, Kowalchuk A, Meyers JA, Seale JP. Equipping residents to address alcohol and drug abuse: the national SBIRT residency training project. J Grad Med Educ 2012 Mar;4(1):58-63 [FREE Full text] [doi: 10.4300/JGME-D-11-00019.1] [Medline: 23451308]
33. Puskar K, Gotham HJ, Terhorst L, Hagle H, Mitchell AM, Braxter B, et al. Effects of screening, brief intervention, and referral to treatment (SBIRT) education and training on nursing students' attitudes toward working with patients who use alcohol and drugs. Subst Abus 2013;34(2):122-128. [doi: 10.1080/08897077.2012.715621] [Medline: 23577905]
34. Bray J. iTunes Preview. 2014. SBIRT URL: https://itunes.apple.com/us/app/sbirt/id877624835?mt=8 [accessed 2016-11-06] [WebCite Cache ID 6lpOiZ4Fn]
35. Bullock A, Dimond R, Webb K, Lovatt J, Hardyman W, Stacey M. How a mobile app supports the learning and practice of newly qualified doctors in the UK: an intervention study. BMC Med Educ 2015 Apr 08;15:71 [FREE Full text] [doi: 10.1186/s12909-015-0356-8] [Medline: 25889996]
36. Raman J. Mobile technology in nursing education: where do we go from here? A review of the literature. Nurse Educ Today 2015 May;35(5):663-672. [doi: 10.1016/j.nedt.2015.01.018] [Medline: 25665926]
37. McNeely J, Strauss SM, Rotrosen J, Ramautar A, Gourevitch MN. Validation of an audio computer-assisted self-interview (ACASI) version of the alcohol, smoking and substance involvement screening test (ASSIST) in primary care patients. Addiction 2016 Feb;111(2):233-244 [FREE Full text] [doi: 10.1111/add.13165] [Medline: 26360315]
38. McNeely J, Wu L, Subramaniam G, Sharma G, Cathers LA, Svikis D, et al. Performance of the Tobacco, Alcohol, Prescription Medication, and Other Substance Use (TAPS) tool for substance use screening in primary care patients. Ann Intern Med 2016 Nov 15;165(10):690-699. [doi: 10.7326/M16-0317] [Medline: 27595276]
39. Kalkhoran S, Appelle NA, Napoles AM, Munoz RF, Lum PJ, Alvarado N, et al. Beyond the ask and advise: implementation of a computer tablet intervention to enhance provider adherence to the 5As for smoking cessation. J Subst Abuse Treat 2016 Jan;60:91-100 [FREE Full text] [doi: 10.1016/j.jsat.2015.05.009] [Medline: 26150093]
40. Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process 1991 Dec;50(2):179-211. [doi: 10.1016/0749-5978(91)90020-T]
41. Kognito Interactive. iTunes Preview. 2016. Change talk: childhood obesity URL: https://itunes.apple.com/us/app/change-talk-childhood-obesity/id821851796?mt=8 [accessed 2016-11-07] [WebCite Cache ID 6lpRos7YF]
42. Epocrates. URL: http://www.epocrates.com/ [accessed 2016-11-07] [WebCite Cache ID 6lpTdcHUd]
43. Roth WR, Vilardaga R, Wolfe N, Bricker JB, McDonell MG. Practical considerations in the design and development of smartphone apps for behavior change. J Contextual Behav Sci 2014 Oct 01;3(4):269-272 [FREE Full text] [doi: 10.1016/j.jcbs.2014.08.006] [Medline: 25485231]
44. Open Health Network. URL: http://www.openhealth.cc/ [accessed 2016-11-07] [WebCite Cache ID 6lpPiQUz3]
45. Hulley S, Newman T, Cummings S, Hearst N, Grady D, Browner W. Designing Clinical Research: An Epidemiologic Approach. 2nd ed. PA: Lippincott Williams & Wilkins; 2001.
46. usability.gov. System Usability Scale (SUS). URL: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html [accessed 2016-11-06] [WebCite Cache ID 6lpNfBPGy]
47. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). Arlington, VA: American Psychiatric Publishing; 2013.
48. Babor T, Higgins-Biddle J, Saunders J, Monteiro M. AUDIT: The Alcohol Use Disorders Identification Test. Guidelines for Use in Primary Care. Second Edition. Geneva: World Health Organization; 2001. URL: http://apps.who.int/iris/bitstream/10665/67205/1/WHO_MSD_MSB_01.6a.pdf [WebCite Cache ID 6pSKGobKg]
49. Knight JR, Sherritt L, Shrier LA, Harris SK, Chang G. Validity of the CRAFFT substance abuse screening test among adolescent clinic patients. Arch Pediatr Adolesc Med 2002 Jun;156(6):607-614. [Medline: 12038895]
50. Winters KC. Development of an adolescent alcohol and other drug abuse screening scale: personal experience screening questionnaire. Addict Behav 1992;17(5):479-490. [Medline: 1332434]
51. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med 2001 Sep;16(9):606-613 [FREE Full text] [Medline: 11556941]
52. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006 May 22;166(10):1092-1097. [doi: 10.1001/archinte.166.10.1092] [Medline: 16717171]
53. Sullivan GM, Artino AR. Analyzing and interpreting data from likert-type scales. J Grad Med Educ 2013 Dec;5(4):541-542 [FREE Full text] [doi: 10.4300/JGME-5-4-18] [Medline: 24454995]
54. Maurer D. iMedicalApps. 2016. Review of UCSF OHN SBIRT app, evidence based intervention for substance abuse URL: http://www.imedicalapps.com/2016/08/ucsf-ohn-sbirt-app-evidence-based-intervention-substance-abuse/ [accessed 2016-11-07] [WebCite Cache ID 6lpQxrAQd]

55. Open Cancer Network. iTunes Preview. 2016. OHN SBIRT URL: https://itunes.apple.com/us/app/ohn-sbirt/id1109510478?mt=8 [accessed 2017-02-17] [WebCite Cache ID 6oLdkPyAy]
56. Muench F. The promises and pitfalls of digital technology in its application to alcohol treatment. Alcohol Res 2014;36(1):131-142 [FREE Full text] [Medline: 26259008]
57. Bullock A, Webb K. Technology in postgraduate medical education: a dynamic influence on learning? Postgrad Med J 2015 Nov;91(1081):646-650 [FREE Full text] [doi: 10.1136/postgradmedj-2014-132809] [Medline: 26341127]
58. Barrio P, Ortega L, Bona X, Gual A. Development, validation, and implementation of an innovative mobile app for alcohol dependence management: protocol for the SIDEAL trial. JMIR Res Protoc 2016 Feb 17;5(1):e27 [FREE Full text] [doi: 10.2196/resprot.5002] [Medline: 26888196]
59. Berman AH, Gajecki M, Sinadinovic K, Andersson C. Mobile interventions targeting risky drinking among university students: a review. Curr Addict Rep 2016;3:166-174 [FREE Full text] [doi: 10.1007/s40429-016-0099-6] [Medline: 27226948]
60. Johnson K, Richards S, Chih M, Moon TJ, Curtis H, Gustafson DH. A pilot test of a mobile app for drug court participants. Subst Abuse 2016;10:1-7 [FREE Full text] [doi: 10.4137/SART.S33390] [Medline: 26917964]
61. Milward J, Khadjesari Z, Fincham-Campbell S, Deluca P, Watson R, Drummond C. User preferences for content, features, and style for an app to reduce harmful drinking in young adults: analysis of user feedback in app stores and focus group interviews. JMIR Mhealth Uhealth 2016 May 24;4(2):e47 [FREE Full text] [doi: 10.2196/mhealth.5242] [Medline: 27220371]
62. Finkelstein J, Cha EM. Using a mobile app to promote smoking cessation in hospitalized patients. JMIR Mhealth Uhealth 2016 May 06;4(2):e59 [FREE Full text] [doi: 10.2196/mhealth.5149] [Medline: 27154792]
63. Torous J, Staples P, Shanahan M, Lin C, Peck P, Keshavan M, et al. Utilizing a personal smartphone custom app to assess the Patient Health Questionnaire-9 (PHQ-9) depressive symptoms in patients with major depressive disorder. JMIR Ment Health 2015;2(1):e8 [FREE Full text] [doi: 10.2196/mental.3889] [Medline: 26543914]
64. Schlosser D, Campellone T, Kim D, Truong B, Vergani S, Ward C, et al. Feasibility of PRIME: a cognitive neuroscience-informed mobile app intervention to enhance motivated behavior and improve quality of life in recent onset schizophrenia. JMIR Res Protoc 2016 Apr 28;5(2):e77 [FREE Full text] [doi: 10.2196/resprot.5450] [Medline: 27125771]
65. Franklin JC, Fox KR, Franklin CR, Kleiman EM, Ribeiro JD, Jaroszewski AC, et al. A brief mobile app reduces nonsuicidal and suicidal self-injury: evidence from three randomized controlled trials. J Consult Clin Psychol 2016 Jun;84(6):544-557. [doi: 10.1037/ccp0000093] [Medline: 27018530]

Abbreviations

PHQ: Patient Health Questionnaire
RCT: randomized controlled trial
SBIRT: screening, brief intervention, and referral to treatment
SUS: system usability scale
TPB: theory of planned behavior

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Protocol

Association Between Workarounds and Medication Administration Errors in Bar Code-Assisted Medication Administration: Protocol of a Multicenter Study

Willem van der Veen[1], PharmD; Patricia MLA van den Bemt[2], PharmD, PhD; Maarten Bijlsma[1], PhD Statistics; Han J de Gier[1], PharmD, PhD; Katja Taxis[1], PharmD, PhD

[1]Faculty of Science and Engineering, Unit PharmacoTherapy, -Epidemiology & -Economics, University of Groningen, Groningen, Netherlands
[2]Erasmus Medical Center, Department of Hospital Pharmacy, Erasmus University, Rotterdam, Netherlands

Corresponding Author:
Willem van der Veen, PharmD
Faculty of Science and Engineering
Unit PharmacoTherapy, -Epidemiology & -Economics
University of Groningen
HPC: XB45
A Deusinglaan 1
Groningen, 9713 AV
Netherlands
Phone: 31 50 363 75 76
Fax: 31 52 361 55 50
Email: willem.van.der.veen@rug.nl

Abstract

Background: Information technology-based methods such as bar code-assisted medication administration (BCMA) systems have the potential to reduce medication administration errors (MAEs) in hospitalized patients. In practice, however, systems are often not used as intended, leading to workarounds. Workarounds may result in MAEs that may harm patients.

Objective: The primary aim is to study the association of workarounds with MAEs in the BCMA process. Second, we will determine the frequency and type of workarounds and MAEs and explore the potential risk factors (determinants) for workarounds.

Methods: This is a multicenter prospective study on internal medicine and surgical wards of 4 Dutch hospitals using BCMA systems to administer medication. We will include a total of 6000 individual drug administrations using direct observation to collect data.

Results: The project was funded in 2014 and enrollment was completed at the end of 2016. Data analysis is under way and the first results are expected to be submitted for publication at the end of 2017.

Conclusions: If an association between workarounds and MAEs is established, this information can be used to reduce the frequency of MAEs. Information on determinants of workarounds can aid in a focused approach to reduce workarounds and thus increase patient safety.

Trial Registration: Netherlands Trial Register NTR4355; http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=4355 (Archived by WebCite at http://www.webcitation.org/6pqTLxc6i).

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KEYWORDS

BCMA; bar code-assisted medication administration systems; workarounds; medication administration errors; bar coded medication administration; medication safety, hospitals

Introduction

Minimizing the risks of prescribing and medication administration is important to enhance patient safety in hospitals [1-6]. Many hospitals have implemented information technology-based systems such as computerized physician order entry (CPOE) systems to reduce prescribing errors [7-10]. Some have also implemented electronic bar code-assisted medication

administration (BCMA) systems to reduce medication administration errors (MAEs) [11-18]. BCMA systems are designed to contribute to patient safety through scanning of the bar code on the medication package and the bar code on the patient's identification wristband to guarantee the 5 "rights" in patient medication administration: right patient, right medication, right dose, right route, and the right time. However, in practice, BCMA systems are not always used as intended, and so-called workaround occurs [19-23]. Kobayashi et al [24] defined workarounds as "informal temporary practices for handling exceptions to normal workflow." Investigating the use of CPOE systems in hospitals, Niazkhani et al [25] described 42 types of workarounds. Koppel et al [26] documented 15 types of workarounds in the BCMA process, including affixing patients' identification bar codes to computer carts and carrying several patients' prescanned medications on carts. That study documented 31 roots of these workarounds. Research on workarounds in the BCMA process focused on the qualitative description of the extent and type of workarounds in the BCMA process [27,28]. Little research has been done to quantify the frequency of workarounds in the BCMA process and investigate the impact of workarounds on patient safety, in particular, MAEs as a potential consequence of workarounds. Furthermore, little is known about the potential risk factors leading to workarounds. Therefore, we designed a study aimed at determining the association of workarounds with MAEs. Our secondary objectives are to determine the frequency and type of workarounds and the frequency and type of MAE, and to identify potential risk factors for workarounds.

Methods

Design

This study is a multicenter prospective observational study in adult patients who are admitted to a participating hospital in the Netherlands and who have their medication administered by BCMA systems.

The regional medical ethics committee (Regionale Medisch Ethische Commissie Zorgpartners Friesland) approved the study protocol. Study data are coded to guarantee the privacy of the participants.

Setting

All included hospitals have implemented CPOE [10] and BCMA systems. They use a variety of software packages, both for the CPOE and for the BCMA systems. As a consequence, procedures for prescribing and medication administration differ between hospitals. Table 1 summarizes the main characteristics. Medication administration procedures within a hospital vary slightly between wards because of differences in patient groups or tasks (eg, in some hospitals, short stay surgical patients do not wear wristbands, but these are attached to the medication cart).

The included hospitals use bar code-labeled unit dose systems to distribute medication to inpatients. In the pharmacy departments, pharmacy technicians dispense bar coded medication for individual patients into trays labeled with the patient's name and bar code. Trays are placed in medication carts in which they are then delivered to the wards once a day (or more frequently). Wards do not have ward-based medication stock (except for emergency medication). One of the selected hospitals uses so-called bedside assortment picking carts [29]. A cart contains all the medication commonly used on the ward. With this system, nurses select the medication for administration during the medication administration rounds.

In general, there are 4 scheduled medication administration rounds in the participating hospitals: 6-10 AM, 10-2 PM, 6-8 PM, and 8-10 PM. Medications are administered by 1 nurse. Nurse trainees are supervised by registered nurses. In the participating hospitals, there are approximately 10-20 inpatients admitted on a ward served by a registered nurse and a nurse trainee. A large ward is split into smaller units each serving 10-20 inpatients, each aided by a registered nurse and a nurse trainee.

During a drug administration round, nurses select the prescribed medication for each inpatient from the prefilled trays or from the bedside assortment picking carts. In addition to the cart, nurses also take along the computer on wheels or the workstation on wheels to access the CPOE system during the drug administration round.

Inpatients do not use their own (out-of-hospital prescribed) drugs.

Participants

The study will enroll patients admitted to the internal medicine and surgical wards of 4 Dutch hospitals in which a BCMA system is used to administer medication. To be eligible to participate in this study, a participant must meet the following criteria: be a hospitalized patient and receive medication on those nursing wards that are participating in this study. We will exclude patients younger than 18 years.

Outcome Measures

The primary outcome measure of the study is the proportion of medication administrations with 1 or more MAEs. For this outcome, we will study the association between the MAE and the occurrence of 1 or more workarounds.

The secondary outcomes are the frequency and type of workarounds, the frequency and type of MAEs in the BCMA process, and the association of potential risk factors with workarounds.

Table 1. Characteristics of the medication administration systems in the participating hospitals.

Item	Hospital 1	Hospital 2	Hospital 3	Hospital 4
Software system	RH Dharma	ViPharma	Klinicom	Pharma
System screen layout	Fixed layout	Fixed layout	Fixed layout	User-controlled screen layout
Administration system	Bedside assortment picking cart	Cart with prefilled patient-labeled trays	Cart with prefilled patient-labeled trays	Cart with prefilled patient-labeled trays
Log-in procedure for nurse	Once; automatic log-out after 15 minutes of inactivity	Once for 1 session	Once for 1 session	Once for 1 session
Log-out procedure for nurse	Manual; automatic log-out after 15 minutes of inactivity	Manual	Manual	Manual
Built-in additional check by nurse's colleagues	Extra log-in for another nurse built in	Not possible	Extra log-in for another nurse built in	Not described in the instructions
Signal/alert system	Scanner beep and scanner warning light	Computer beep	Computer beep	Computer beep
Patient has no bar code	Not described in the instructions	Manual patient selection	Manual patient selection	Manual patient selection
Patient selection per administration round	Once, by selection of patient; automatically deselected after all medication for that round is administered	Twice, by selection and active deselection of patient after medication administration	Once, by selection of patient; automatic deselection after all medication for that round is administered	Once, by selection of patient; automatic deselection after all medication for that round is administered
Medication in the cart has no bar code	Robot-packed bar coded medication ordered from pharmacy	Manual drug selection	Manual drug selection	Nurse can overrule the system using her or his access code and manually select drug
More than 1 unit of the same drug for the same time prescribed	Scanned once, then the number of tablets is manually adjusted	Every drug unit is scanned	Scanned once, then the number of tablets is manually adjusted	Scanned once; a pop-up appears asking for the other tablets to be scanned
Patient away or sleeping	Prescribed medication is placed at the patients' bedside, registered as given, and checked at 2:00 AM	Medication not given and not registered; noted in memo field	Medication not given and not registered; noted in memo field	Not described in the instructions
One-half or one-quarter of a tablet prescribed	Tablet scanned, plus code "half" or "quarter" scanned on computer	Not described in the instructions	Tablet scanned, plus noted by nurse in memo field on the screen	Not described in the instructions
Instructions on screen for nurse from pharmacy or prescriber	On-screen memo field included (medication data level)	On-screen memo field included (patient data level)	On-screen memo field included (medication data level)	On-screen memo field included (medication data level)

We will collect the following potential risk factors for workarounds using a structured data collection form (Multimedia Appendix 1): nurses' characteristics (experienced, trained, or student nurse; nurses' satisfaction with BCMA), workload characteristics (number of nurses on the ward, number of patients served by that ward, number of medicines per round per patient, number of medicines for all patients per round per ward), BCMA system characteristics (time after implementation of BCMA system on that ward, bar code on medication unit dose), medication characteristics (Anatomical Therapeutic Chemical Classification System [ATC] code of the medication, drug administration route), and general characteristics (hospital type, ward type, time of ward round, patient age and sex). We will ask the supervisor of the ward for data on the nurses' education and experience. We will extract the number of patients on the ward, the medication and ATC code, and the number of drugs to administer to each individual patient during the specific administration rounds from the CPOE system. We will ask the supervising hospital pharmacist for the other risk factors.

Data Collection

We will use disguised observation [30-34] to collect data. A total of 3 trained observers (undergraduate students, writing their master's thesis) from the School of Pharmacy, University of Groningen and Utrecht University, the Netherlands, will observe the nurses while they give drugs to inpatients. To prevent nurses adjusting their behavior in the BCMA process while under observation, the observer will be introduced as being on the ward to monitor the performance of the medication distribution system on that ward. The observer will take part in several planned medication administration rounds on that ward and also observe unscheduled medication administrations. The observer will randomly pick a medication administration round with a minimum of 3 rounds every day and a weekly minimum of 18 rounds. During the different rounds, the observer will

observe as many different nurses as possible. To prepare for the observation, the observer will study the standard operating procedures or the applicable drug administration procedures of the specific ward and the agreements on the BCMA process of that ward. In practice, the observer will accompany the nurse who administers the medication using the BCMA system and observe the administration of each dose of medication to the patient. The observer will record the nurses' actions of giving drugs to the patients (according to the forms in Multimedia Appendix 1,Multimedia Appendix 2, and Multimedia Appendix 3). After each observed medication administration round, we will collect a (printed) computer output of the medication for that specific patient, day, and round from the hospital's electronic patient records. Consequently, we will compare observation records with the prescribed medication on this computer output and with available standard operating procedures of the BCMA process for that specific ward, to identify workarounds and MAEs. We designed an Access database in which we will record the observation data and which we will link to each patient's prescription and medication data.

If the observer becomes aware of a potentially serious error, the observer will intervene for ethical reasons, but the data will be included in the study.

Training of the Observers

We will train our observers by having them study relevant literature on observational techniques [19,30,34-40], perform practical observations in a nonparticipating hospital under the supervision of the research team, and complete a written theoretical exam. The observers will have to pass the exam scoring 8 out of 10 points, having two chances to pass the exam. In case of a second failure, he or she will not be able to observe. Each observer will do pilot observations in a participating hospital, supervised by 1 of the researchers, for 1 week on the wards, to become familiar with the BCMA process. Pilot observations will be discussed with the research team. These observations are meant as a final training of the observer. Pilot data will be discarded.

Definitions and Classification

Workarounds are defined as "informal temporary practices for handling exceptions to normal workflow" for that specific ward and are operationalized as deviations from the available protocols [24]. Figure 1 depicts the BCMA workflow and the potential risk factors for workarounds in the BCMA process. We will classify workarounds using a self-developed classification system (Table 2) derived from the system of Koppel et al [26]. Workarounds can be related to patient identification, the scanning process, the alert signals, and other procedures, or can be work related. Allan and Barker [41] defined MAEs as "the administration of a dose of medication that deviates from the prescription as written (or ordered by CPOE) on the patient medication chart, or from standard hospital policy and procedures." We will compare drug administrations with the doctor's prescriptions as noted in the CPOE system in the pharmacy database. We will exclude intravenous and nonintravenous preparation errors because these errors are not preventable by BCMA and are thus unlikely to be influenced by workarounds in the BCMA process. We will classify the MAEs using the classification of van den Bemt et al [42] (Table 3). We will divide the number of erroneous medication administrations (containing 1 or more errors) by the number of observed drug administrations plus the number of omissions, thus using the concept of opportunities for errors as in other MAE research [43].

Figure 1. Flowchart of the bar code-assisted medication administration (BCMA) process in hospitals.

Table 2. Classification of workarounds in the bar code-assisted medication administration process[a].

Workaround type	Example workaround
Procedure related: standard operating procedure, or procedure unclear or unknown	Nothing scanned
Patient related: no patient wristband or patient not in the room	Bed scanned, or loose wristband scanned, patient unscanned
Medication related: medication not bar coded	Unscanned, unidentified medication given
Nurse related: nurse disturbed	Nurse forgets patient or gives medication twice
Computer or scanner related: computer or scanner down or broken	Signals or alerts unseen, unscanned medication given
Other workarounds	Medication scanned for multiple patients; half tablets scanned as full dose

[a]Derived from Koppel et al [26].

Table 3. The most basic characterization of medication administration errors (MAEs)[a].

MAE type	Example MAE
Omission	Drug prescribed, but not administered
Unordered drug administration	Drug administered, but not prescribed
Wrong dosage form	Drug dosage form administered to the patient deviating from prescribed dosage form: solution as an alternative to tablet
Wrong route of administration	Drug given by a wrong route of administration: oral liquid administered intravenously
Wrong administration technique	Drug administered using a wrong technique: intravenous push instead of intravenous infusion
Wrong dosage	Drug dosage too high or low: 20 mg instead of 20 µg
Wrong time of administration	Drug given at least 60 minutes too early or too late

[a]From van den Bemt et al [42].

Sample Size Calculation

Prior studies [14,44-46] on the effect of BCMA show a substantial reduction (about 30%) of errors after the implementation of BCMA (from 14.4%, or 4743 errors in 32,972 observations, to 9.9%, or 2651 errors in 26,892 observations). The error rate of about 10% is a mix of all resulting errors, including those caused by workarounds. The purpose of our sample size calculation is to estimate the number of observations needed to reject the null hypothesis with a power of 90%. We performed a pilot study in 4 Dutch hospitals that were partially using BCMA (these hospitals did not participate in our final research) and found MAE rates, including time window errors caused by nurses and based on workarounds, fluctuating from 2% to 20% (2%, 4%, 5%, and 20%). We assume in our sample size calculation that 8% of medication administrations per patient per nurse result in a workaround. We also assume that the MAE rate associated with a workaround is 2-fold compared with the situation without a workaround; that gives us a relative risk of 2. With alpha of .05 and a power of 0.9, we need to observe 1500 individual medication administrations to patients per hospital to reject the null hypothesis.

Data Monitoring

We will enter all data into an Access database (version 2010, Microsoft Corporation). The basis for the Access database will be the case report forms in Multimedia Appendix 1,Multimedia Appendix 2, and Multimedia Appendix 3. The first (Multimedia Appendix 1) is designed to collect data on potential risk factors for workarounds, the second (Multimedia Appendix 2) is designed to collect data on MAEs, and the third (Multimedia Appendix 3) is designed to collect data on observations of workarounds. These data will be made available to other researchers and editors on request. Data entry errors will be minimized by using multiple choice options and fixed data fields. At the end of the study, 10% of the entered data will be checked by a second researcher. If data entry errors are found, additional portions of 10% of the data will be checked until no errors are found within a portion. Also, a periodic backup of the study database of each hospital will be made and checked for missing data. Access to the research databases will be secured by passwords. Changing the format of the study documentation or study databases will be restricted to the primary investigator. New versions will be distributed from the central study location (the University of Groningen, the Netherlands). Before data analysis, we will lock the final database.

Statistical Analysis

Data will be analyzed using IBM SPSS Statistics version 22 (IBM Corporation). We will analyze the potential association between workarounds and the occurrence of MAEs using univariate multilevel logistic regression, with the proportion of medication administrations with 1 or more errors as the dependent variable and the occurrence of workarounds as the independent variable. The nurse and the patient will be the levels in the multilevel analysis. We will analyze the occurrence of workarounds as a categorical variable, with the following categories: no workarounds (reference category), 1 workaround, 2 workarounds, and 3 or more workarounds. We will adjust for potential confounders by using multivariate multilevel logistic regression. The parameters in the multivariate multilevel logistic regression model will be hospital, ward type, day of the week, time schedule of medication administration rounds, ATC code, the number of drugs per patient per round, and the route of administration. We will report the adjusted odds ratio and 95% confidence interval. For the frequency and type of workarounds and MAEs, we will use descriptive statistics. Univariate and multivariate logistic regression will determine the association of the risk factors with the workarounds.

Results

The project was funded in 2014 and enrollment was completed at the end of 2016. Data analysis is under way and the first results are expected to be submitted for publication at the end of 2017.

Discussion

The Dutch BCMA study investigates the complex and multifaceted process of medication administration to hospital inpatients. Computer technology can assist not only the prescribing and dispensing of drugs, but also their administration. Several studies have shown that BCMA systems can contribute to patient safety in this final step of the medication distribution process [11-18]. On the other hand, computer technology can give rise to new MAEs, as is described

in the literature [47]. Many of these errors occur at the human-machine interface, for example, due to inadequate training or understanding of the system or inadequate equipment. Such factors may lead to workarounds that may compromise patient safety. Although several articles have been published describing workarounds in a qualitative way, very little is known on whether they are associated with a higher risk of MAEs.

Strengths and Limitations

The strength of the Dutch BCMA study is that it will provide quantitative information about workarounds and their possible association with MAEs, as one of the first studies worldwide, to our knowledge. Other strengths are the multicenter design, which enhances its generalizability, and the robust method of data collection by disguised observation.

There are some limitations and considerations, however. An important limitation, in general, is that the use of BCMA cannot prevent all MAEs. For example, BCMA systems will have no influence on the preparation of intravenous and nonintravenous medication. So, although this study will contribute to patient safety, further studies into other ways of preventing MAEs will remain necessary.

Although disguised observation is the best method for data collection in MAE studies, some limitations are associated with this technique. Despite thorough training of the observers, bias may still occur. To overcome observation bias, we considered the use of the work observation method by activity timing [34,48]. This elegant paperless method is used for time- and activity-based observations and is less suitable for observing workarounds and MAEs.

The observations may influence the nurse but, from the literature, we know that this effect (known as Hawthorne effect) [49,50] is small. The observer may also become tired and thus less accurate. How to train observers is not well documented in the literature. Patterson et al [19] performed an observational study in acute and long-term care wards using observers trained in ethnographic observations in complex settings. Other researchers trained nurse students as observers [51]. We will use all possible means, as well as the best possible literature base, to train the students.

We will try to reduce confounding by applying multivariate regression analyses (eg, hospital type, type of ward). However, in this type of observational study design, residual confounding may always remain [52].

Last but not least, we plan to conduct our research on internal medicine and surgical hospital wards. Although these nursing wards cover a broad range of patient categories, our findings cannot be generalized to all patient categories.

Conclusion

BCMA has the potential to minimize the occurrence of MAEs, but workarounds may compromise this. Knowing how nurses overcome process barriers by using workarounds and their association with MAEs will produce opportunities to further increase patient safety in the process of BCMA.

Authors' Contributions

WV, PB, and KT designed the study and drafted the manuscript. MB and HG made substantial contributions to the design of the protocol. All authors read and approved the final manuscript.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Potential risk factors form.

[PDF File (Adobe PDF File), 15KB - resprot_v6i4e74_app1.pdf]

Multimedia Appendix 2

Medication administration errors observation form.

[PDF File (Adobe PDF File), 16KB - resprot_v6i4e74_app2.pdf]

Multimedia Appendix 3

Workarounds observation form.

[PDF File (Adobe PDF File), 15KB - resprot_v6i4e74_app3.pdf]

References

1. Breckenridge RA. Technology and patient safety: only part of the solution. Br J Hosp Med (Lond) 2010 Oct;71(10):544-545. [doi: 10.12968/hmed.2010.71.10.78934] [Medline: 21085067]
2. Hagland M. CPOE and patient safety. Healthc Inform 2011 Jun;28(6):76-78. [Medline: 21736218]

3. Handel DA, Wears RL, Nathanson LA, Pines JM. Using information technology to improve the quality and safety of emergency care. Acad Emerg Med 2011 Jun;18(6):e45-e51 [FREE Full text] [doi: 10.1111/j.1553-2712.2011.01070.x] [Medline: 21676049]
4. Holden RJ. What stands in the way of technology-mediated patient safety improvements?: a study of facilitators and barriers to physicians' use of electronic health records. J Patient Saf 2011 Dec;7(4):193-203 [FREE Full text] [doi: 10.1097/PTS.0b013e3182388cfa] [Medline: 22064624]
5. Wulff K, Cummings GG, Marck P, Yurtseven O. Medication administration technologies and patient safety: a mixed-method systematic review. J Adv Nurs 2011 Oct;67(10):2080-2095. [doi: 10.1111/j.1365-2648.2011.05676.x] [Medline: 21545642]
6. Institute of Medicine. Health IT and Patient Safety: Building Safer Systems For Better Care. Washington, DC: The National Academies Press; 2012.
7. Aarts J, Koppel R. Implementation of computerized physician order entry in seven countries. Health Aff (Millwood) 2009;28(2):404-414 [FREE Full text] [doi: 10.1377/hlthaff.28.2.404] [Medline: 19275996]
8. van Doormaal JE, Mol PG, Zaal RJ, van den Bemt PM, Kosterink JG, Vermeulen KM, et al. Computerized physician order entry (CPOE) system: expectations and experiences of users. J Eval Clin Pract 2010 Aug;16(4):738-743. [doi: 10.1111/j.1365-2753.2009.01187.x] [Medline: 20545801]
9. Hollister D, Messenger A. Implementation of computerized physician order entry at a community hospital. Conn Med 2011 Apr;75(4):227-233. [Medline: 21560729]
10. van der Veen W, de Gier HJ, van der Schaaf T, Taxis K, van den Bemt PM. Risk analysis and user satisfaction after implementation of computerized physician order entry in Dutch hospitals. Int J Clin Pharm 2013 Apr;35(2):195-201. [doi: 10.1007/s11096-012-9727-y] [Medline: 23187963]
11. Agrawal A, Glasser AR. Barcode medication. Administration implementation in an acute care hospital and lessons learned. J Healthc Inf Manag 2009;23(4):24-29. [Medline: 19894483]
12. Marini SD, Hasman A. Impact of BCMA on medication errors and patient safety: a summary. Stud Health Technol Inform 2009;146:439-444. [Medline: 19592882]
13. Helmons PJ, Wargel LN, Daniels CE. Effect of bar-code-assisted medication administration on medication administration errors and accuracy in multiple patient care areas. Am J Health Syst Pharm 2009 Jul 1;66(13):1202-1210. [doi: 10.2146/ajhp080357] [Medline: 19535659]
14. DeYoung JL, Vanderkooi ME, Barletta JF. Effect of bar-code-assisted medication administration on medication error rates in an adult medical intensive care unit. Am J Health Syst Pharm 2009 Jun 15;66(12):1110-1115. [doi: 10.2146/ajhp080355] [Medline: 19498127]
15. Young J, Slebodnik M, Sands L. Bar code technology and medication administration error. J Patient Saf 2010 Jun;6(2):115-120. [doi: 10.1097/PTS.0b013e3181de35f7] [Medline: 22130354]
16. Miller DF, Fortier CR, Garrison KL. Bar code medication administration technology: characterization of high-alert medication triggers and clinician workarounds. Ann Pharmacother 2011 Feb;45(2):162-168. [doi: 10.1345/aph.1P262] [Medline: 21285409]
17. Holden RJ, Brown RL, Alper SJ, Scanlon MC, Patel NR, Karsh B. That's nice, but what does IT do? Evaluating the impact of bar coded medication administration by measuring changes in the process of care. Int J Ind Ergon 2011 Jul 01;41(4):370-379 [FREE Full text] [doi: 10.1016/j.ergon.2011.02.007] [Medline: 21686318]
18. Berdot S, Gillaizeau F, Caruba T, Prognon P, Durieux P, Sabatier B. Drug administration errors in hospital inpatients: a systematic review. PLoS One 2013;8(6):e68856 [FREE Full text] [doi: 10.1371/journal.pone.0068856] [Medline: 23818992]
19. Patterson ES, Rogers ML, Chapman RJ, Render ML. Compliance with intended use of bar code medication administration in acute and long-term care: an observational study. Hum Factors 2006;48(1):15-22. [doi: 10.1518/001872006776412234] [Medline: 16696253]
20. Van Der Sijs H, Rootjes I, Aarts J. The shift in workarounds upon implementation of computerized physician order entry. Stud Health Technol Inform 2011;169:290-294. [Medline: 21893759]
21. Rathert C, Williams ES, Lawrence ER, Halbesleben JR. Emotional exhaustion and workarounds in acute care: cross sectional tests of a theoretical framework. Int J Nurs Stud 2012 Aug;49(8):969-977. [doi: 10.1016/j.ijnurstu.2012.02.011] [Medline: 22391337]
22. Seidling HM, Lampert A, Lohmann K, Schiele JT, Send AJ, Witticke D, et al. Safeguarding the process of drug administration with an emphasis on electronic support tools. Br J Clin Pharmacol 2013 Sep;76 Suppl 1:25-36 [FREE Full text] [doi: 10.1111/bcp.12191] [Medline: 24007450]
23. Voshall B, Piscotty R, Lawrence J, Targosz M. Barcode medication administration work-arounds: a systematic review and implications for nurse executives. J Nurs Adm 2013 Oct;43(10):530-535. [doi: 10.1097/NNA.0b013e3182a3e8ad] [Medline: 24061586]
24. Kobayashi M, Fussell S, Xiao Y, Seagull F. Work coordination, workflow, and workarounds in a medical context. New York, NY: ACM Press; 2005 Presented at: CHI '05 Extended Abstracts on Human Factors in Computing Systems; Apr 2-7, 2005; Portland, OR, USA p. 1561-1564. [doi: 10.1145/1056808.1056966]

25. Niazkhani Z, Pirnejad H, van der Sijs H, Aarts J. Evaluating the medication process in the context of CPOE use: the significance of working around the system. Int J Med Inform 2011 Jul;80(7):490-506. [doi: 10.1016/j.ijmedinf.2011.03.009] [Medline: 21555237]
26. Koppel R, Wetterneck T, Telles JL, Karsh B. Workarounds to barcode medication administration systems: their occurrences, causes, and threats to patient safety. J Am Med Inform Assoc 2008;15(4):408-423 [FREE Full text] [doi: 10.1197/jamia.M2616] [Medline: 18436903]
27. Rack LL, Dudjak LA, Wolf GA. Study of nurse workarounds in a hospital using bar code medication administration system. J Nurs Care Qual 2012;27(3):232-239. [doi: 10.1097/NCQ.0b013e318240a854] [Medline: 22202186]
28. Henneman PL, Marquard JL, Fisher DL, Bleil J, Walsh B, Henneman JP, et al. Bar-code verification: reducing but not eliminating medication errors. J Nurs Adm 2012 Dec;42(12):562-566. [doi: 10.1097/NNA.0b013e318274b545] [Medline: 23151928]
29. Ros H, De Vreeze-Wesselink E. Reducing the number of dispensing errors by implementing a combination of a CPOE system and a bar-code-assisted dispensing system: the BAP concept. Eur J Hosp Pharm Sci 2009;15(4):86-92.
30. Barker KN, Flynn EA, Pepper GA. Observation method of detecting medication errors. Am J Health Syst Pharm 2002 Dec 01;59(23):2314-2316. [Medline: 12489369]
31. Berdot S, Sabatier B, Gillaizeau F, Caruba T, Prognon P, Durieux P. Evaluation of drug administration errors in a teaching hospital. BMC Health Serv Res 2012 Mar 12;12:60 [FREE Full text] [doi: 10.1186/1472-6963-12-60] [Medline: 22409837]
32. Wirtz V, Taxis K, Barber ND. An observational study of intravenous medication errors in the United Kingdom and in Germany. Pharm World Sci 2003 Jun;25(3):104-111. [Medline: 12840963]
33. Westbrook JI, Woods A. Development and testing of an observational method for detecting medication administration errors using information technology. Stud Health Technol Inform 2009;146:429-433. [Medline: 19592880]
34. Westbrook JI, Ampt A. Design, application and testing of the Work Observation Method by Activity Timing (WOMBAT) to measure clinicians' patterns of work and communication. Int J Med Inform 2009 Apr;78 Suppl 1:S25-S33. [doi: 10.1016/j.ijmedinf.2008.09.003] [Medline: 18951838]
35. Holmwood C. Direct observation. A primer for supervisors of doctors in training. Aust Fam Physician 1998;27(1-2):48-51. [Medline: 9503706]
36. Moravansky I. [Training in observation as a means of promotion of personality development]. Osterr Krankenpflegez 1996 Apr;49(4):30-31. [Medline: 8788712]
37. Riemer JW. A review with a special note on research ethics and disguised observation. Wisc Sociol 1977;14(2-3):87-97. [Medline: 11650450]
38. Unertl KM, Weinger MB, Johnson KB. Applying direct observation to model workflow and assess adoption. AMIA Annu Symp Proc 2006:794-798 [FREE Full text] [Medline: 17238450]
39. van der Sande JP. Gedragsobservatie. Een Inleiding tot Systematisch Observeren. 3rd edition. Groningen, the Netherlands: Martinus Nijhoff; 1999.
40. Cristoph L, van der Sande JP. Gedragsobservatie. Systematisch Observeren. 1st edition. Groningen, the Netherlands: Wolters-Noordhoff; 1999.
41. Allan EL, Barker KN. Fundamentals of medication error research. Am J Hosp Pharm 1990 Mar;47(3):555-571. [Medline: 2180287]
42. van den Bemt P. Drug-related problems: definitions and classifications. Eur J Hosp Pharm Pract 2006;12(suppl):10-12.
43. Keers RN, Williams SD, Cooke J, Ashcroft DM. Prevalence and nature of medication administration errors in health care settings: a systematic review of direct observational evidence. Ann Pharmacother 2013 Feb;47(2):237-256. [doi: 10.1345/aph.1R147] [Medline: 23386063]
44. Poon EG, Keohane CA, Yoon CS, Ditmore M, Bane A, Levtzion-Korach O, et al. Effect of bar-code technology on the safety of medication administration. N Engl J Med 2010 May 6;362(18):1698-1707. [doi: 10.1056/NEJMsa0907115] [Medline: 20445181]
45. McLeod MC, Barber N, Franklin BD. Methodological variations and their effects on reported medication administration error rates. BMJ Qual Saf 2013 Apr;22(4):278-289. [doi: 10.1136/bmjqs-2012-001330] [Medline: 23322752]
46. Hassink JJ, Essenberg MD, Roukema JA, van den Bemt PM. Effect of bar-code-assisted medication administration on medication administration errors. Am J Health Syst Pharm 2013 Apr 01;70(7):572-573. [doi: 10.2146/ajhp120257] [Medline: 23515508]
47. Cheung K, van der Veen W, Bouvy ML, Wensing M, van den Bemt PM, de Smet PA. Classification of medication incidents associated with information technology. J Am Med Inform Assoc 2014 Feb;21(e1):e63-e70 [FREE Full text] [doi: 10.1136/amiajnl-2013-001818] [Medline: 24064444]
48. Westbrook JI, Creswick NJ, Duffield C, Li L, Dunsmuir WT. Changes in nurses' work associated with computerised information systems: opportunities for international comparative studies using the revised Work Observation Method By Activity Timing (WOMBAT). NI 2012;2012:448 [FREE Full text] [Medline: 24199139]
49. Gale EA. The Hawthorne studies-a fable for our times? QJM 2004 Jul;97(7):439-449. [Medline: 15208432]
50. Dean BS, Barber ND. A validated, reliable method of scoring the severity of medication errors. Am J Health Syst Pharm 1999 Jan 01;56(1):57-62. [Medline: 10048880]

51. Kim J, Bates DW. Medication administration errors by nurses: adherence to guidelines. J Clin Nurs 2013 Feb;22(3-4):590-598. [doi: 10.1111/j.1365-2702.2012.04344.x] [Medline: 23228148]
52. Mann B, Wood E. Confounding in observational studies explained. Open Epidemiol J 2012 May 16;5(1):18-20. [doi: 10.2174/1874297101205010018]

Abbreviations

ATC: Anatomical Therapeutic Chemical Classification System
BCMA: bar code-assisted medication administration
CPOE: computerized physician order entry
MAE: medication administration error

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Protocol

A Mobile App for Chronic Disease Self-Management: Protocol for a Randomized Controlled Trial

Raymond L Ownby[1], MD, PhD, MBA; Amarilis Acevedo[2], PhD; Drenna Waldrop-Valverde[3], PhD; Joshua Caballero[4], PharmD; Michael Simonson[5], PhD; Rosemary Davenport[1], MSN, ARNP-BC; Kofi Kondwani[6], PhD; Robin J Jacobs[7], PhD, MSW, MS, MPH

[1]Nova Southeastern University, Department of Psychiatry and Behavioral Medicine, Fort Lauderdale, FL, United States

[2]Nova Southeastern University, College of Psychology, Fort Lauderdale, FL, United States

[3]Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, United States

[4]Larkin Health Sciences Institute, Department of Clinical and Administrative Sciences, College of Pharmacy, Miami, FL, United States

[5]Department of Instructional Design and Technology, Fischler College of Education, Nova Southeastern University, Fort Lauderdale, FL, United States

[6]Department of Community Health and Preventive Medicine, Morehouse School of Medicine, Atlanta, GA, United States

[7]Baylor College of Medicine, Department of Family and Community Medicine--Research Programs, Houston, TX, United States

Corresponding Author:
Raymond L Ownby, MD, PhD, MBA
Nova Southeastern University
Department of Psychiatry and Behavioral Medicine
Room 1477
3200 South University Drive
Fort Lauderdale, FL, 33314
United States
Phone: 1 9542621481
Fax: 1 9542623236
Email: ro71@nova.edu

Abstract

Background: Health literacy is a critically important skill that helps people become active participants in their health care. Multiple studies in the United States and across the world have documented the association of health literacy with multiple health outcomes. In particular, the elderly and many members of minority groups have been shown to have low levels of health literacy; the same groups are disproportionately affected by chronic illnesses. These twin burdens affect the people most in need of the skills and knowledge required for coping with chronic illnesses. Chronic disease self-management (CDSM) is a logical target for a general health literacy intervention. In an approach that spans across specific diseases, CDSM targets problems and skills needed to cope with issues such as fatigue, pain, stress, depression, sleep disturbance, and treatment adherence. In a previous study, we showed that a computer-delivered tailored information intervention targeting health literacy could improve treatment and adherence and be cost effective, but it is not clear that this same strategy will be effective in persons with low health literacy and multiple chronic conditions.

Objective: The purpose of this study is to develop a computer-delivered mobile intervention that will provide individuals with chronic conditions the necessary information to cope with their conditions.

Methods: In this project, we will complete a qualitative study on the status and needs of individuals with more than one chronic condition. Results of this study will be used to develop a mobile tailored information app that will address self-management challenges in the areas of pain, sleep, fatigue, depression, anger, stress, memory problems, and treatment adherence. The impact of the intervention on patient quality of life, patient-provider relationships, health literacy, and patient activation will be assessed. We will also explore the extent to which health literacy mediates important outcomes, such as health-related quality of life and health service utilization.

Results: We are currently completing the preliminary qualitative and usability studies that will inform the content and design of the intervention. We anticipate that the intervention will be complete in 2017, and the clinical trial of its efficacy will also commence in 2017.

Conclusions: Results will provide evidence on the usefulness of a mobile tailored information app for improving health literacy, patient activation, health-related quality of life, and self-reported health in patients with multiple chronic conditions.

Trial Registration: Clinicaltrials.gov NCT02922439; https://clinicaltrials.gov/ct2/show/NCT02922439 (Archived by WebCite at http://www.webcitation.org/6pTiqDAyN)

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KEYWORDS

health literacy; chronic disease self-management; health disparities; patient activation; health related quality of life; mobile health technology

Introduction

Low Health Literacy and Disparities

Health literacy is a critically important ability that is a key route by which people can become active participants in their health care. The 2003 National Assessment of Adult Literacy in the United States showed that more than 75 million Americans had, at best, only basic health literacy skills, suggesting that as many as 1 in 4 are unable to understand the complexities of health care [1]. The importance of health literacy is underscored by multiple studies that have linked levels of health literacy to health status and outcomes [2-4] that even include risk of death [5,6]. Persons in racial/ethnic minorities and the elderly are even more likely to have low levels of health literacy. Twenty-four percent of blacks (9.5 million persons), 41% of Hispanics (21 million persons), and 29% of persons 65 years of age or older (12.5 million persons) have below-basic levels of health literacy [1], suggesting that they may be unable to use health information for even the most basic tasks, such as following simple directions on how to take a medicine. The ability to effectively obtain, interpret, and use relevant information to maintain health and cope with illness is increasingly important in today's complex health care system, in which patients are required to take more responsibility for their care [7]. Further highlighting the importance of health literacy, compelling evidence links race and age to health via health literacy [3,8-12]. In the proposed study, we will assess the potential moderating effect of race, ethnicity, and age in response to an intervention to improve health literacy (Aim 3, discussed below).

Need for Downstream Interventions Targeting Disparities

While the causes of health disparities are broad, complex, and rooted in social, cultural, and economic factors [13,14], health care services are still delivered to at-risk individuals every day. An urgent need exists for *downstream* interventions that can affect health disparities at the point of care [15]. Interventions that improve patients' ability to manage their own health care may be especially critical given ongoing changes in the US health care system, which requires patients to take greater responsibility for their personal and family health care decisions [7,16,17], even as the system becomes more complex for underserved minorities [18] and the elderly [19]. Provisions of the Affordable Care Act in the United States, for example, specifically promote shared decision-making and the development of patient decision-making aids [20] to address these issues.

Multimorbidity and Chronic Disease Self-Management

Chronic disease self-management (CDSM) is a logical target for a downstream intervention to address disparities and low health literacy. CDSM skills involve a wide variety of strategies that can be implemented by patients themselves to cope with chronic conditions. These strategies can include, for example, cognitive techniques for managing chronic pain (eg, distraction, reframing) or behavioral techniques (eg, graded exercise for fatigue and shortness of breath). While specific health conditions may require disease-related management skills (eg, glucometer use in diabetes), common issues such as fatigue, depression, stress, sleep disturbance, and treatment adherence span across illnesses and can be addressed in a single intervention; several of these have been the focus of a previously developed in-person group-delivered CDSM intervention [21-24]. In this continuation of our research on health literacy, we will expand on other interventions by first completing a qualitative study to inform the development of a general CDSM intervention. We will use the measure of health literacy created in an earlier study [25-27] to evaluate participants' levels of health literacy and provide them with a version of the intervention tailored to their level of health literacy, preferred language, and race or ethnicity. In the proposed study, we will evaluate the effectiveness of a tailored intervention to improve health literacy (Aim 2, discussed more extensively below).

Chronic Disease Self-Management and Health Literacy

CDSM integrates well with our previously developed and validated model of health literacy [26]. In the Abilities-Skills-Knowledge (ASK) model of health literacy, we argue that health literacy performances (such as finding and acting upon information about a disease) depend on general cognitive abilities (verbal reasoning, attention, working memory), specific skills (eg, reading and listening comprehension), and disease-related knowledge [26]. While efforts to improve basic cognitive abilities have been met with limited success, it is clear that patients can learn specific skills that will facilitate their understanding of oral and written health information, and can also learn conceptual knowledge about diseases. Created prior to the explicit formulation of the ASK model, the intervention targeting health literacy in persons treated for human immunodeficiency virus (HIV) [28-30] followed its principles and demonstrated the effectiveness of the instructional strategies discussed below. In this study, participants showed improvements in disease-related information

and medication adherence [30]. An important finding in this study was that race-related differences in disease information were no longer significant after black participants completed the intervention [30]. In the project discussed in this paper, we will draw on this experience, as well as our current pilot study of an ASK model-based intervention for diabetes, in creating an efficacious intervention to improve health literacy in individuals with multiple chronic health conditions.

An alternate strategy to provide patients with the skills and knowledge to understand and manage their health is also important, because the dominant format for information delivery to patients in clinical care is oral communications during brief (and often rushed) clinical encounters [31]. Patient learning in these contexts is often suboptimal, at levels substantially less than 50% of the material presented [32], and during these encounters providers often fail to provide key information [33,34]. Unfortunately, it may be difficult or impossible to help patients develop self-management skills if they do not have basic health-related reading and math skills or health-related knowledge. Health literacy is likely to be an essential aspect of developing CDSM skills.

The ASK model will be the explicit basis for the development of our mobile app. We will first complete a qualitative study to better understand the skills and knowledge needs of individuals with both self-management needs and low health literacy. Results of this qualitative study will inform the development of the intervention. The ASK model will provide a general framework for the content of the intervention, while the results of the qualitative study will provide a guide to its content.

Health Literacy Interventions

The previously developed conceptual model of health literacy [26] states that health literacy, after considering demographic variables, comprises basic cognitive *abilities*, relevant academic *skills*, and health care-related conceptual *knowledge* (ASK). An advantage of this model is that it leads directly to interventions. While it may be difficult to change patients' basic cognitive abilities, interventions can readily be developed to improve patients' skills at acquiring and understanding health information, along with their knowledge of health conditions and treatment. Strategies used in previous studies to improve patients' health literacy have included providing information, improving skills (eg, reading comprehension), and targeting psychosocial constructs (eg, self-efficacy or patient activation) [3]. Reviews of these studies suggest that while some strategies were useful, no clear consensus on methods, content, or their effectiveness has emerged [3,8,35,36]. Expert recommendations for health literacy interventions include rejecting a *one size fits all* approach [37], creating interventions that promote participant engagement and retention through interactivity and interesting multimedia elements, and ensuring learning through an interactive teach-evaluate-reteach algorithm when needed [29,30,38,39]. The planned project will follow these recommendations in creating a tailored, interactive, and multimedia intervention to improve CDSM skills in participants with low levels of health literacy.

Tailoring content to make interventions more personally relevant and appropriate to patients' levels of health literacy has been advocated as an effective strategy for health communication [40-42]. Tailoring can promote engagement and facilitate behavior change, as previously demonstrated in minority populations and those with low levels of education and computer skills [42-45]. Tailoring interventions to enhance racial and ethnic relevance enhances interventions' effects for blacks [46,47] and Hispanics [48]. Other authors, including those who created national guidelines for the US Department of Health and Human Service's *Healthy People 2020* and from the US Centers for Disease Control, stress the need to deliver materials that are matched to patients' levels of health literacy [49-51]. Brouwer [52] noted that greater personal relevance may be related to increased likelihood of successful dissemination of computer-delivered health care interventions. Jerant et al [43] summarized research on computer-tailored health interventions and concluded that these interventions are a, "highly promising" strategy for reducing health disparities. Individualization of information and teaching strategies can be undertaken in small groups by skilled educators, but it is not clear how the health care system would find the number of educators needed or how they would be paid. Computer-based interventions can provide similar tailoring to larger numbers of patients at lower costs [39,43].

Expected Outcomes of a Chronic Disease Self-Management Health Literacy Intervention

Effects of a successful health literacy intervention targeting CDSM are likely to go beyond improved knowledge and skills. Francis et al [53] showed, for example, that improving low-literacy patients' reading skills also had a positive impact on their mood, and a study completed by our group showed that an intervention to improve health literacy in persons treated for HIV had a modestly positive (but nonsignificant) effect on control beliefs [29]. Hibbard et al [54] showed that an intervention to develop chronic disease management skills was associated with increases in patient activation, and Lorig et al [55] showed changes in patient self-efficacy for managing their health conditions after a chronic disease management program. During the evaluation of a health literacy intervention for CDSM, it will be important to measure not only health literacy as a specific outcome, but also to assess the effects of the intervention on other health care-related variables, including activation and utilization. In this study, we will also evaluate the effects of the intervention on problems that span across diseases, such as pain, sleep, stress, depression, and treatment adherence [56].

Study Objectives

In a previous study, Fostering Literacy for Good Health Today/Vive Desarollando Amplia Salud (FLIGHT/VIDAS), we developed a new measure of health literacy [25]. The new measure was validated with respect to other measures of health literacy as well as health-related quality of life [27]. Data from the study were then used to posit and test the ASK model of health literacy, which could be directly linked to improved health literacy [26]. In the proposed study, we will adapt and deploy the FLIGHT/VIDAS health literacy measure on tablet computers (Aim 1, see below), use it to evaluate a participant's health literacy, and feed this information forward to tailor the

CDSM health literacy intervention to a level of health literacy that is appropriate for each participant. Data from the study will also be used to further explore the paths among race, ethnicity, age, health literacy, and health.

Although it has been shown that computer-delivered tailored information interventions may be effective in improving health literacy in specific patient groups [28,29,43,44,57], it is not clear whether the same sort of computer-delivered, multimedia, and interactive approach will be effective in improving CDSM-related health literacy skills in persons with low baseline levels of health literacy. If the strategy is effective, it is also not clear whether effects will extend beyond health literacy and target symptoms (eg, depression, pain, or adherence) to quality of life, self-efficacy, and patient activation. The effects of this intervention will be compared to an active control group consisting of a similar intervention presented without tailoring, and each group will be examined for effects on health literacy, health status, health self-efficacy, patient activation, and treatment adherence.

In addition to the overall goal of assessing the usefulness of a tablet-delivered app, this study will further several other project-related goals, including the ongoing development of the FLIGHT/VIDAS health literacy measure in its tablet adaptation. The utility of alternate forms of the measure and their sensitivity to intervention effects will be evaluated, and a final goal of the study is to use these data to explore the complex relationships among race, ethnicity, health literacy, and health status.

Aims and Hypotheses

In Aim 1 we will adapt and evaluate the tablet computer-administered measure of health literacy developed during an earlier study with African-American, Hispanic, and white non-Hispanic individuals 40 years of age and older, which operated on tablet computers. The two hypotheses of Aim 1 are: (*Hypothesis 1*) alternate forms of the new health literacy measure's general health literacy and numeracy scales will be sensitive to intervention effects, showing improvements after participants complete the intervention; and (*Hypothesis 2*) the new health literacy measure will be acceptable, usable, and valid when administered on tablet computers.

In Aim 2 we will use the computer-administered measure to assign participants to a racially- and ethnically-tailored intervention that is delivered in a way that is appropriate to their level of health literacy. The two hypotheses of Aim 2 are: (*Hypothesis 3*) an interactive multimedia intervention will be more effective in improving health literacy, self-reported health, patient activation, health self-efficacy, and treatment adherence compared to a matched active control intervention; and (*Hypothesis 4*) the interactive multimedia intervention tailored to participants' characteristics will significantly reduce health literacy differences between white non-Hispanics, African-Americans, and Hispanics.

In Aim 3 we will assess mediators and moderators of the relation of health literacy to race and ethnicity. We will also explore how these mediators and moderators are linked to health behaviors and actual health outcomes. The two hypotheses of Aim 2 are: (*Hypothesis 5*) health literacy will mediate relations between age, race and ethnicity, socioeconomic status, cognition, academic skills, and health status; and (*Hypothesis 6*) health literacy will moderate response to the health literacy intervention, with blacks and Hispanics with lower initial levels showing a greater response to the intervention than white non-Hispanics with higher levels of health literacy.

Methods

Study Design

In Phase 1 of the study we will: (1) complete a qualitative study of critical chronic disease management skills and knowledge with key informants and patients, (2) use the results of the qualitative study to inform the development of a tailored computer-delivered CDSM health literacy intervention, and (3) complete acceptability and usability testing of the tablet-delivered version of FLIGHT/VIDAS and the intervention. In Phase 2, we will complete a clinical trial of the effects of the new intervention on multiple outcome measures.

Phase 1

During the qualitative procedures in Phase 1, individual interviews will be completed with at least 20-30 individuals with a chronic disease (at least one chronic condition from planned inclusion criteria for Phase 2; sampling will continue until saturation is reached). Purposive sampling will be employed so that age, gender, race, language, and chronic conditions are adequately represented. During an earlier study, participants completed a questionnaire asking whether they had been diagnosed with specific health conditions. Results from this questionnaire will be used to recruit these same persons for Phase 1 procedures, based on the specific health conditions that were reported earlier. We will target individuals with a variety of conditions, as well as those with multiple conditions.

Interviews will be conducted in English or Spanish at Nova Southeastern University in Fort Lauderdale, Florida and at Emory University in Atlanta, Georgia, and information will be digitally recorded and transcribed for subsequent analyses. In-depth interviews will also be completed with 10 key informants (5 English-speaking and 5 Spanish-speaking) selected from diverse disciplines, who are familiar with the treatment of chronic illnesses, including: geriatric, internal, and family medicine; nursing; and social work. Interviews will be open-ended but will be semistructured to make it possible to elicit informants' input on each of the key problems in chronic disease management that span across conditions. These problems include: fatigue, pain or physical discomfort, shortness of breath, sleep problems, depression, anger, stress, memory problems, and adherence.

After preliminary analyses, four focus groups will be completed (28 total participants, with one group in Spanish) with participants who are also representative of potential consumers of the intervention, to provide checks on concordance and trustworthiness of the themes identified in interviews. During these focus group sessions, we will solicit suggestions that more accurately represent the life situations of our study population.

Although interviews will cover the same material, interview content will be tailored to each participant's unique situation.

Within each area, there will be several subareas designed to further understand these phenomena. We will use NVivo for Windows, Version 10 (Melbourne, Australia: QSR International) to assist in coding data, searching text, and conducting cross-case analyses. An inductive thematic analysis will be used, as this technique allows for the patterns, themes, and categories of analysis to emerge [58]. The software allows for a process that incorporates an emic approach to analysis, and allows for an exploration of indigenous concepts and typologies. The study design will allow for a consideration of the credibility of themes elicited in individual interviews by cross-checking them with focus group participants and key informants. In the final part of Phase 1, content modules will be refined and modified, based on this iterative process and using data from the interviews.

Intervention materials focusing on behavioral self-management skills will be created for each problem area (eg, exercise and self-guided cognitive behavioral interventions for pain [59], meditation for stress [60], behavioral activation for depression [61,62], cognitive behavioral interventions for sleep disturbances [63], and our own model for treatment adherence [29,38]). All key problems in chronic disease management listed above will be assessed by measures in our battery at baseline and all follow-ups, allowing for direct evaluation of the intervention's effects on specific CDSM problems.

Interventions

Information from this qualitative phase will lay the basis for developing general content modules that are consistent with the ASK model of health literacy [26]. This process will draw specific content from established domains of chronic disease management by teaching health literacy skills and health condition conceptual knowledge.

Interventions will be developed that are consistent with recommended strategies for persons with limited literacy skills [64,65]. All materials will use health care-related content as a vehicle (eg, prose about diseases or a table about desirable blood sugars). Intervention elements will focus on the three basic literacy types, as defined by the Educational Testing Service: prose, document, and quantitative [66]. Consistent with research on the effectiveness of direct training in reading comprehension for adult learners [67], training in prose comprehension will focus on strategies to develop functional skills such as identifying key facts, inductive reasoning from multiple facts, and self-monitoring of comprehension. Training in document literacy will use tables, charts, and health-related forms (eg, insurance, consent) and emphasize strategies for identifying key information and strategies for using the information to answer relevant questions (eg, "Which insurance program is better for me?"). Training for quantitative skills will integrate basic instruction on quantitative concepts and procedures for understanding risk, probability, and cost [68,69].

Content

Information from the qualitative phase will allow us to develop general content modules that will focus on the key problems in chronic disease management listed above. Key strategies will be to teach health literacy skills and improve health condition-related knowledge. Problems, needed and useful skills, and disease-related conceptual knowledge revealed in qualitative work will then be used by investigators to create a content outline for each module. Content-relevant skills will be integrated with condition-related knowledge in each module (eg, by teaching reading comprehension skills using materials that are directly related to health). We will use a similar strategy in teaching listening comprehension by focusing on encounters with healthcare providers. This might involve teaching strategies for preparing a list of questions before an appointment, taking notes during the encounter, and being appropriately assertive in interactions.

Cognitive load theory [70,71] dictates that for optimal learning, instructional material must be presented in segments of content that do not exceed the learner's ability to take in and retain each element. Consideration of this issue may be especially important in persons with limited health literacy [72]. Consistent with this issue, material will be presented in small segments via text and audio, with graphic elements reinforcing themes but not distracting from participants' learning [70]. Interactions with the computer will only require that participants tap on the screen to press images of buttons, thereby keeping required computer skills to a minimum.

In a series of team meetings, content created by individual team members will be reviewed and alternate versions will be created at the three reading levels planned for each intervention group (3^{rd}, 6^{th}, and 8^{th} grade levels) based on the Flesch-Kincaid formula for English [73] and its Fernandez-Huerta modification for Spanish [74]. No clear criterion for the difficulty of health-related materials is available for use in tailoring, so we will use the criterion of grade equivalent levels. In this context, however, it will measure the difficulty of *health-related* materials and thus materials will be tailored to participants' levels of health literacy.

Intervention content will be developed in either English or Spanish, with versions translated by team members fluent in the target language, with an emphasis on appropriate cultural adaptation rather than literal translation [75]. This strategy was previously effective in creating a health literacy measure in both English and Spanish [25], and helped to ensure that both language versions were intelligible to individuals from diverse linguistic and cultural backgrounds. Given the importance of regional usages of Spanish (eg, the same word may mean different things in Puerto Rico or Mexico), the Spanish version will be developed with an emphasis on standard Spanish to avoid comprehension problems. Intervention content will be assessed during usability testing, in addition to a focus on interface design and ease of use.

Usability Testing

After creation, acceptability and usability testing of the new materials will be completed using a procedure that we successfully used in other projects [76,77]. Individuals will be observed interacting with the computer app and will be asked to *think out loud* [78] so that their cognitive processes can be tracked, and areas of difficulty can be identified [76]. After five participants have completed this process, the intervention will be revised and tested again with a new group of five participants

[77]. This process will be repeated until no further difficulties are identified, potentially eliciting responses from 15 to 20 participants [79,80].

Technology

Implementation will allow participants to monitor their own progress and provide centralized data collection. The intervention will be created in standard off-the-shelf software, *Captivate* (Adobe Corporation; San Jose, California), which is widely used in developing educational media. This software has been used in previous projects due to its ease of use, integration of multimedia elements, and simple deployment to most learning management systems. The current version (*Captivate 9*) creates apps in HTML5/CSS/JavaScript formats that can be readily deployed on Windows, iOS, and Android devices, and on the Internet. Output from this program can be readily packaged as downloadable apps for the operating systems of most mobile devices, including iOS (iPhone, iPad), Android, and Windows Phone.

Tablet Computer Adaptation

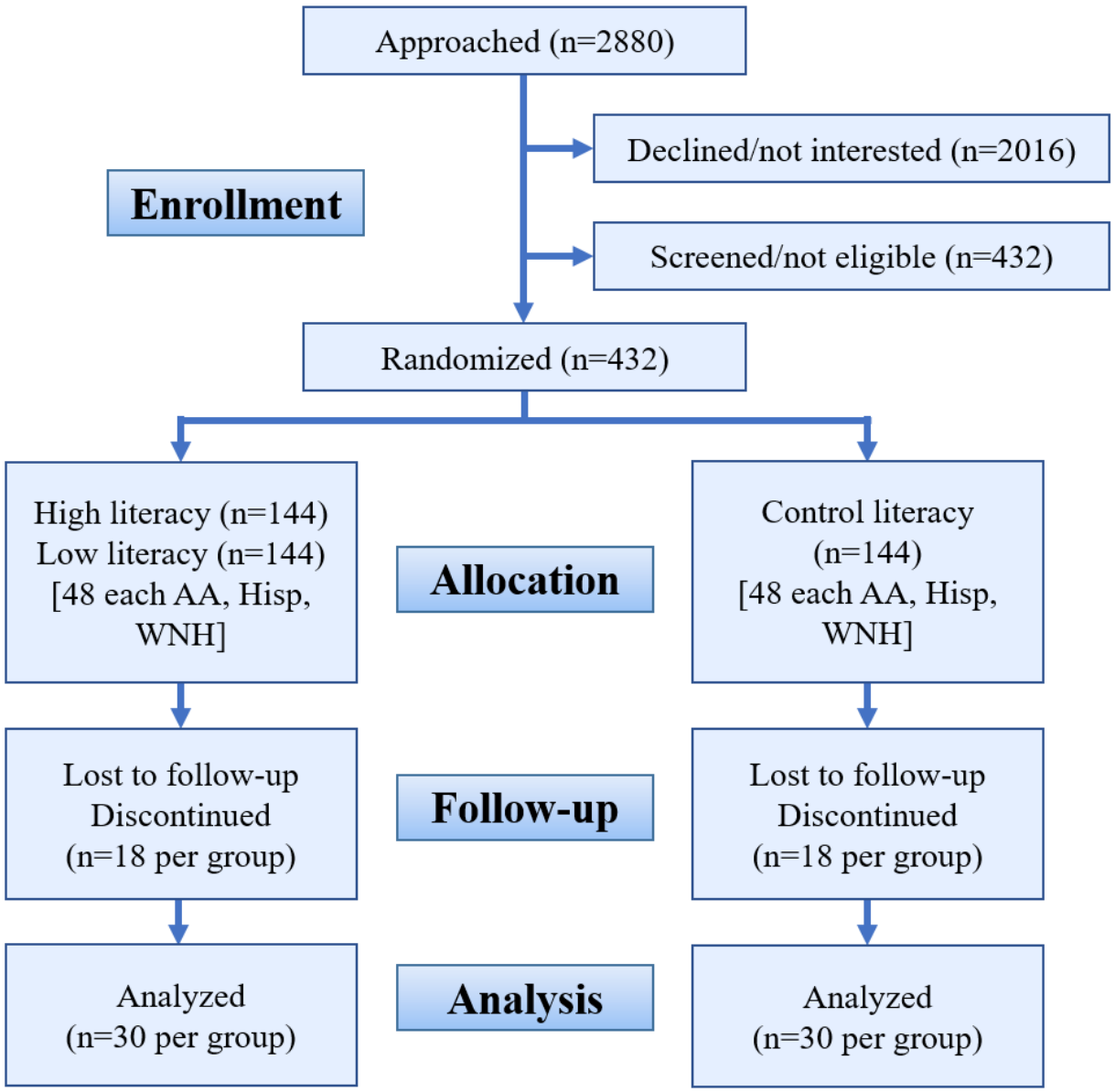
Delivery of FLIGHT/VIDAS on tablet computers will require modifications to the size of graphics, layout of page elements, and changes in font sizes. The file size for graphic elements will be reduced to improve download times over the Internet. Studies continue to show a dramatic increase in Internet use among older persons [81] and multiple studies show that elders evaluate the usability of tablet computers positively [82-84]. We will ask all participants to complete FLIGHT/VIDAS and the health literacy intervention on tablet computers, but it is possible that some of the oldest participants may not be able to do so. All participants in our previous study were able to complete assessments on touch screen computers (94 of whom were 70 years of age or older), so participants who have difficulty (ie, express frustration or state that they are not able to accurately record responses) with tablet computers will use the larger-format touch screen.

Phase 2

Participants

We will recruit Spanish- and English-speaking persons aged 40 years and older whose health literacy is at the 8th grade level or lower. Literacy levels will be assessed via validated scores on the Rapid Estimate of Adult Literacy in Medicine (REALM) [85], or the Short Assessment of Health Literacy in Spanish Speaking Adults (SAHLSA) [86]. This level was chosen to include persons in the lower end of the basic proficiency level and below, as defined by the US National Assessment of Adult Literacy [1,87-89]. The REALM and SAHLSA were selected based on their demonstrated relation to health status in other studies and data from our previous study that enabled us to use them as screening tools. The intervention will thus target those most likely to profit from instruction at a moderate difficulty level approximately two grade levels lower than this (6th grade), or those who may need low-literacy level instruction (3rd grade) based on their instructional reading level being approximately two grade equivalents below the tested level. English-speaking participants will include approximately equal numbers of African-Americans and non-Hispanic whites, with recruitment stratified by age decades (to enhance existing FLIGHT/VIDAS norms) from age 40, with no upper limit. Considering the importance of broadening the geographic basis of our normative population and ensuring the usefulness of the health literacy intervention for diverse groups, in the proposed study we will expand data collection to include Grady Memorial Hospital in cooperation with our collaborators at the Morehouse School of Medicine and Emory University (all in Atlanta, Georgia). We will continue to recruit African-American, white non-Hispanic and Hispanic participants at our Nova Southeastern University site, as we did in our earlier project. During this project, we plan to expand our recruiting efforts in South Florida to include larger numbers of Spanish speakers with low educational backgrounds who are originally from Mexico. We will randomize 432 participants, as needed (216 at each site; see power analyses for sample size justification, below). Numbers of participants in Figure 1 reflect planned recruitment based on power analysis and potential attrition.

Figure 1. Patient recruitment and flow. Numbers reflect planned enrollment based on power analyses and potential attrition. AA: African-American or Afro-Caribbean; Hisp: Hispanic; WNH: white non-Hispanic.



Treatment Assignment

Inclusion and Exclusion Criteria

Participants will be eligible for the study if they are 40 years of age or older, are treated for at least one of the conditions in the Functional Comorbidity Index [90] (cardiovascular disease, arthritis, cancer, lung disease, osteoporosis, depression, and others) with at least one medication, have health literacy below the 8th grade level as indicated by the REALM (English) or SAHLSA (Spanish), and are willing to participate for the length of the study. Potential participants will be excluded if they are not able to provide informed consent, have a cognitive or psychiatric disorder that impairs their ability to safely participate in the study, or are not able to remain involved over the full length of the study.

A screening procedure for the new project was developed by assessing the ability of the REALM [85] or SAHLSA [91] to predict if participants had an 8th grade or lower level of reading on the Woodcock-Johnson or Muñoz reading tests. Using the R statistical package pROC [92], a score of 62 on the REALM predicted reading skills less than an 8th grade level on the Woodcock-Johnson (area under the curve [AUC]=0.79, 95% CI 0.72-0.87; sensitivity=0.80, specificity=0.67) with similar results for the SAHLSA. Earlier analyses showed that the FLIGHT/VIDAS General Health Literacy (HL) scale will also be effective for use in detecting participants with lower levels

of reading skills (all *P*- values <.001). Analyses did not differ for language groups (AUC for Spanish sample=0.86, *P*<.001).

Recruitment and Retention

Recruitment at the Atlanta sites will take place in the Primary Care clinics of Grady Health Services and Emory Healthcare. Grady Health Services is the largest public health provider in Georgia, and fifth largest in the nation, with more than 130,000 outpatient visits per year. Emory Healthcare has satellite clinics throughout metro-Atlanta and serves a broad array of patient demographics and backgrounds. In current studies, it is possible to access the electronic medical record to prescreen study participants. We will continue this practice after obtaining Institutional Review Board (IRB) permission. The study recruiter will identify potential participants meeting inclusion criteria; he or she will then meet with clinic staff and providers, supply them with study information (flyers, brochures), and ask the clinic staff/provider to give the study information to these potential participants. Passive recruitment through study flyers and information about the study on clinic phone-wait systems will also be used. All studies utilizing these procedures are currently on target with recruitment goals.

In addition to a pool of subjects who participated in prior studies and have given permission to contact them in future studies, Spanish-speaking Hispanics will be recruited from Nova Southeastern University internal, family, and geriatric medicine clinics. Special efforts will be made to recruit a diverse group of Hispanics representative of South Florida and the rest of country's Hispanic population, per US census data, particularly with respect to country of reference and educational attainment. In our previous study, we recruited more than 320 Spanish-speaking Hispanics over 3 years of active recruitment [25-28].

Interventions

Participants in the experimental groups will use modules that are tailored on three key dimensions: (1) preferred language (English or Spanish), (2) level of health literacy (3^{rd} or 6^{th} grade), and (3) racial or ethnic relevance (using verbal and graphic elements that will enhance the relevance of the material to African-Americans, Hispanics, or non-Hispanic whites). In the experimental groups, the intervention will add a fourth dimension of tailoring by providing individual feedback on understanding, via ongoing assessment of learning and review of material that is not yet mastered. The intervention content will be closely linked to the ASK model of health literacy [26] by targeting skills and knowledge related to CDSM, as informed by results of the qualitative study in Phase 1.

Participants in the control group will view informational screens and answer questions similar to the experimental group, but materials will be presented at the standard and widely recommended 8^{th} grade reading level (the approximate average reading level of adults in the United States [93]) to simulate the literacy demands that participants typically encounter when using health care information. Materials will not be tailored for race or ethnicity, except that Spanish speakers will complete the intervention in their preferred language.

What Will Participants Actually Do?

A typical intervention session will begin with the participant being greeted by study staff and directed to a touchscreen computer station. The study assistant will ensure that the patient has begun the correct study module (eg, self-management of sleep problems). The participant will view screens that present basic information on types of sleep disorders and their causes. After presentation of a discrete amount of information, a review screen is presented to consolidate learning (eg, "Common causes of insomnia are…"). The next several screens will present questions to check participants' learning; if questions are answered incorrectly, the program loops to a review of the topic with a second presentation and check question. Specific sections of the intervention will focus on improving information search skills via computer-coached materials that facilitate comprehension of written materials on insomnia (eg, "What is the major point of this paragraph?") and Internet information search skills (ie, how to find more information on the Internet). In addition, coaching on interacting with health care providers (eg, writing down questions before visits, or taking a friend with you who can help you remember what the doctor says) will be woven throughout the modules.

Procedures

Participants will be recruited through advertisements, publicity at local clinics and senior centers, and presentations at local organizations. After initial contact, participants will be scheduled for a screening visit during which their eligibility for the study will be established via an interview to assess demographics, current treatment for at least one health condition, and level of health-related reading using the REALM or SAHLSA. During the baseline visit, participants will complete cognitive and psychosocial assessments and be oriented to the health literacy intervention. This visit will include baseline assessment of participants' health literacy with Form A of the General HL and Numeracy (NUM) scales of FLIGHT/VIDAS. Participants will then be randomly assigned to the control or active condition, with assignment to low or high health literacy within the active intervention group based on HL scores. Participants in all groups will then complete three weekly visits (approximately 2 hours long) during which they will complete the health literacy intervention. All participants will thus complete 6 hours of the intervention. Final level of material attained will be recorded for use as a covariate in analyses, since some participants may progress more rapidly than others. At the end of the five weeks, participants will complete a postassessment visit during which they will complete Form B of the HL and NUM scales, along with the other outcome measures. Three months after this follow-up visit, participants will be asked to return for a final follow-up visit during which they will complete Form C (a combination of items from Forms A and B) of the HL and NUM scales and the same postintervention assessments of general health, activation, self-efficacy, and self-reported treatment adherence. At each follow-up visit, only measures hypothesized to be affected by the intervention will be administered. See Multimedia Appendix 1 for a detailed schedule of assessments.

Randomization and Blinding

After confirmation of eligibility, participants will be randomized to treatment condition according to a computer-generated schedule using the randomization procedures available in Research Electronic Data Capture (REDCap) electronic data capture tools hosted at Nova Southeastern University [94]. The principal investigator at each site (RLO, DWV) will be responsible for each treatment assignment.

Measures

Primary outcome measures will be health literacy (FLIGHT/VIDAS), self-reported general health (Medical Outcomes Study 36-item Short Form; SF-36 [95]), health self-efficacy (Chronic Disease Self-Efficacy Scale [96]), patient activation (Patient Activation Measure [97]), and treatment adherence. Additional data will provide the ability to consider race, ethnicity, age, and other variables as potential confounders. These data will include demographic variables, mood [98], stress [99], patient-provider relationships [100], treatment engagement, general cognitive abilities, academic skills, health conditions, current symptoms, health care attitudes, self-efficacy [101], and health care utilization.

Severity and number of health conditions will be assessed with the Functional Comorbidity Index [90], a previously validated measure linked to physical status, and an index based on the Midlife in the United States study [102] protocol, as used in our earlier study [27], to allow comparisons with data from that study. Assessments will include information on the specific symptoms of key problems in chronic disease management, and will allow a pre/postevaluation of the effects of the intervention on each. Simple measures of physical status (walking speed [103], body mass index [104], and waist-hip ratio [105]) will also be obtained to assess the effects of health literacy, cognition, and comorbidity on these variables, as they have all been related to risks for mortality [6,106,107].

Most self-report instruments will be administered via Automated Computer-Assisted Self-Interview (ACASI) software with assessment materials presented on touchscreen computers. This strategy enhances data collection by allowing participants anonymity in their responses and reduces issues with hand scoring of measures and manual data entry. Both sites will use the ACASI software Questionnaire Development System (QDS; Nova Research, Bethesda, Maryland). Individually administered measures, including assessments of cognitive, academic, and health literacy status, will be hand scored and verified. QDS output files will be transferred between sites using encrypted file transfer technology also available in REDCap.

The intervention will be standardized by its computer-based presentation across sites, but assessments and interactions with site workers must also be standardized to ensure fidelity across sites. Procedures will be standardized via visit flow sheets accompanied by training and monitoring visits by the investigators at each site. To ensure secure retention delivery of data across sites, all data will be entered into the REDCap software twice [94]. Each entry will be compared using utilities in REDCap and discrepancies will be resolved via inspection of original paper-based data collection instruments.

Data Safety and Monitoring

All assessment procedures planned in this study are either standard psychological or educational procedures (or are similar to standards), and all interventions are similar to typical educational interventions, so we believe that all interventions are associated with minimal risk to participants. We do not anticipate the need for a formal data safety monitoring board for this study, but we will follow a data safety monitoring plan. The plan will require ongoing monitoring of participants' reactions to assessment and intervention activities with formal logs recording any events suggestive of participant distress, frustration, or boredom. All study personnel will be instructed on the importance of recording any relevant events in study logs, the contents of which will be reported on a monthly basis to the principal investigator for minor incidents, and immediately for any serious event (eg, substantial indication of participant distress such as crying, expression of desire to discontinue participation due to emotional upset, or request for emotional assistance due to of feelings or thoughts triggered by assessments). All events will be tracked and reviewed via regular conference calls with site principal investigators for determination of what changes in study procedures should be made to ensure the safety of participants.

Given the length of the study and frequency of study visits, we will be able to maintain close contact with all participants in an ongoing fashion. We will be able to develop and maintain a relationship with each participant that facilitates communication about their reactions to the study. Study personnel will be trained to be alert for signs of emotional upset or frustration in participants as a reaction to study procedures, and will be proactive in approaching participants about their emotional states. Participants will be offered supportive counseling if indicated, and referral for other services if needed.

Finally, we will routinely assess (both formally and informally) participants' reactions to the study using interviews and an ACASI questionnaire that will allow them to privately express any concerns or problems related to the study. We will actively monitor participants' experience in the study, both informally in exit interviews and formally via their responses to ACASI questionnaires, to determine if the study is excessively stressful or upsetting.

Informed Consent and Confidentiality

Informed consent is a process that will begin with IRB review of all recruitment materials. All study personnel will complete mandatory training in the protection of human subjects in research, including the courses of study contained in the Collaborative Institutional Training Initiative program [108], as required by the IRBs of Nova Southeastern University and Emory University, and only trained personnel will be involved in the process. The informed consent process will continue as study personnel explain study procedures during the education process preceding the request for written informed consent.

Participants will be protected from the risk of inadvertent disclosure of their health status or other health-related information by identifying all study-related data collection instruments by the participant's study number. Participants'

identities will only be linked to data via a list that includes participant names and contact information and their participant identification number. All study databases will be kept on password-protected computers or secure servers (REDCap). Paper copies of all materials will be kept in locked filing cabinets in the investigators' offices.

Institutional Review Board Approval

Phase 1 (qualitative) study procedures were approved by the IRBs of Nova Southeastern University and Emory University. Phase 2 (clinical trial) study procedures have received preliminary approval by the IRBs of Nova Southeastern University and Emory University. Final approval is pending development and board review of actual intervention materials prior to their use with participants. Written informed consent will be obtained from all participants.

Data Analyses

Initial Data Management

Initial review will evaluate data for completeness and valid characteristics through inspection of descriptive statistics. Although every effort will be made to minimize loss to follow-up, we recognize that some attrition is likely to occur. We will evaluate patterns of missingness in the data and follow widely-recommended procedures for dealing with this issue [109]. If our evaluation shows that missing data can be considered as missing at random (MAR) then our use of full-information maximum likelihood routines in MPlus statistical software (Muthén & Muthén; Los Angeles, California) will result in unbiased estimates of parameters [110]. If data are not MAR, we will include pattern of missingness in random effects pattern mixture analyses [111]. Group equivalence on demographic characteristics (except those defining group membership) and baseline measures not used in assignment will be assessed, and if differences are found these variables will be used as covariates in analyses. Other analyses will evaluate the distributional properties of dependent variables to assess the suitability of planned statistical models.

Study Hypotheses

Hypotheses will be tested via three aims, detailed below.

Aim 1

Hypothesis 1 regarding the sensitivity of alternate forms of the health literacy measure to the intervention will be tested by calculating the simple sum of the HL and NUM scales for baseline (Form A) and first follow-up (Form B), and test their difference via paired *t*-tests, since this is a straightforward strategy that might be used in research and clinical work. This hypothesis will also be evaluated using a mixed-effects regression model with repeated measures for all three assessments that will include relevant covariates such as race/ethnicity, age, education, and cognition. Models for completers and intent-to-treat groups will be created. *Hypothesis 2*, regarding the validity of the measure on tablet computers, will be assessed by evaluating item difficulties and discriminations, calculation of scales' internal reliabilities (Cronbach alpha), evaluation of construct validity via examination of the measure's factor structure, and evaluation of concurrent validity as correlations and partial correlations of FLIGHT/VIDAS scales with other measures (Test of Functional Health Literacy in Adults, REALM, and SAHLSA). Measures of scale characteristics (mean, standard deviation, Cronbach alpha, and correlations with other measures) will be compared to values obtained for the full-size computer administration obtained during an earlier study [25] using tests for differences in means, standard deviations, and correlations.

Aim 2

Hypotheses 3 and *4* for this aim, related to the effects of the intervention on outcomes, will also be evaluated in mixed-effects regression models including relevant covariates, with separate models assessing each dependent variable (HL and NUM scales, SF-36 General Health, Chronic Disease Self-Efficacy Scale, Patient Activation Measure, and treatment adherence) providing the ability to evaluate between-groups differences and the interaction of group membership (each racial/ethnic group). Estimated marginal means for mixed-effects models will be compared across levels of effects. Exploratory analyses will evaluate the effect of the intervention on other outcomes, such as patient-provider relationships, treatment engagement, and health care service utilization. Exploratory analyses will evaluate the impact of age on these outcomes. Similar analyses will evaluate the effect of the intervention on specific conditions, such as pain, sleep, and fatigue.

Aim 3

Hypotheses 5 and *6* for this aim, related to the significance of effects of race, cognition, socioeconomic status, and academic skills on health status and utilities (as mediated by health literacy) will be tested using structural models developed in the MPlus statistical software. The significance of indirect (mediating) effects will be tested using bias-corrected bootstrapped estimates. *Hypothesis 6*, which suggests that levels of health literacy will moderate the effects of the intervention, will be tested by creating an interaction variable and including it in the structural model for *Hypothesis 5*.

Power Analyses

Power analyses were evaluated using procedures available in the software program *PASS 11* (NCSS, LLC; Kaysville, Utah). The effect sizes used were drawn from studies of reading interventions for low- and high-ability readers, and on the effects of our computer-delivered intervention on participant knowledge. Results show that a total sample size of 30 per group (high vs low vs control health literacy; African-American vs Hispanic vs non-Hispanic white), after possible attrition in any group of up to 38% (yielding at least 30 persons per group), will provide powers greater than 0.90 to test main effects and 0.80 or greater to test the interaction of time by group or by treatment condition. Power is adequate for all two-way interactions; the power to detect all three-way interactions would require a very large sample size that would be excessively costly. We will evaluate higher-level interactions even when not significant to assess the possibility of their presence.

Expected Outcomes

Results of this study will help to establish the utility of the FLIGHT/VIDAS health literacy measure when administered

on convenient tablet computers, including its validity in relation to other measures of health literacy and academic measure of reading and mathematics. Evaluation of the effects of tailoring strategies, and especially of providing information at a level appropriate for our participants' level of health literacy, will provide a test of the usefulness of this strategy in general, and specifically as a way to test racial and ethnic disparities in knowledge and health status. Finally, mediation analyses will allow an assessment of the mediating effect of health literacy on health disparities.

Dissemination and Sustainability

While not directly addressed in the study design, our development and evaluation strategy is focused on making the intervention more widely available in the long-term. A key aspect of this long-term strategy has been the decision to develop the intervention using a medium (HTML5/CSS/JavaScript) and responsive design strategy to ensure that the intervention can be deployed across operating systems and devices. In addition, while emphasis on responsive design will complicate the authoring and usability testing processes, this approach will help us to create an intervention that is widely usable across different devices and formats. The intervention can readily be made available over the Internet, and our development process also allows for packaging of the intervention as a downloadable app. Such apps can be posted for free download on mobile devices and be installed on commercial sites including the Apple Store, Google Play, and Windows store.

Results

We are currently completing the preliminary qualitative and usability studies that will inform the content and design of the intervention. Analyses of these studies suggest that the planned intervention may be helpful to persons with multiple chronic conditions by providing information about management strategies. Results have also suggested the importance of spiritual and religious beliefs in coping with chronic diseases, and we are planning to incorporate this finding into the intervention. We anticipate that the intervention will be complete in 2017, and the clinical trial of its efficacy will also commence in 2017.

Discussion

This study seeks to evaluate the efficacy of a mobile tablet computer intervention in targeting low health literacy directly, as a strategy to address health disparities. In a previous study of persons with HIV infections, the strategy of providing an interactive multimedia intervention that gave participants information tailored for personal relevance and level of understanding resulted in significant improvements in knowledge and treatment adherence [29]. In this project, we seek to build on this intervention strategy to specifically address the learning needs of individuals with low levels of health literacy. We will assess the impact of tailored interventions not only related to condition-specific problems, but also on broader outcomes such as health-related quality of life, patient activation, patient-provider relationships, and treatment adherence.

An important aspect of our development strategy will be the completion of a qualitative study that will inform the development of intervention content. Completion of usability testing, again with likely consumers, will help to ensure that the intervention will have a format and content that is likely to be useful to older persons with chronic conditions. It is hoped that this preliminary work will help to ensure the eventual acceptance of the intervention by a broader audience. The mobile format of the intervention will lend itself to use by persons who may not otherwise have been able to benefit from education on CDSM. While CDSM programs are provided in many locations, delivery of the programs in electronic formats may address some barriers (eg, rural residence, need to travel to a training site, and scheduling difficulties), especially for older persons who are employed.

Although it will be necessary for the dissemination of the intervention to follow development and the demonstration of its utility, it will be created with to the final goal of eventual widespread dissemination through the mobile app deployment system, and via the Internet. Another possible route of dissemination is for the intervention to be made available through patient portals that allow patients to access their health records. Most electronic health records that provide portals make provision for patient education, and the content developed in the planned study might be made available through this outlet as well. Providers would be able to prescribe that patients review material, thereby reducing the time spent in repetitive education activities, while facilitating a positive relationship with patients by providing the opportunity for interaction on patient questions.

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Authors' Contributions

RLO, AA, RJJ, RD, and DWV conceived the project, participated in writing the grant applications, and helped to prepare the manuscript. MS, JC, and KK helped refine intervention content and prepare the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Summary Statement from Previous Grant Reviews.

[PDF File (Adobe PDF File), 174KB - resprot_v6i4e53_app1.PDF]

Multimedia Appendix 2

Summary Statement from Previous Grant Reviews.

[PDF File (Adobe PDF File), 174KB - resprot_v6i4e53_app2.PDF]

References

1. Kutner M, Greenberg E, Jin Y, Paulsen C. The health literacy of America's adults: results from the 2003 National Asessment of Adult Literacy (NCES 2006-483). Washington, DC: US Department of Education, National Center for Educational Statistics; 2006. URL: https://nces.ed.gov/pubs2006/2006483.pdf [accessed 2017-01-05] [WebCite Cache ID 6nICXUnCI]
2. Dewalt DA, Berkman ND, Sheridan S, Lohr KN, Pignone MP. Literacy and health outcomes: a systematic review of the literature. J Gen Intern Med 2004 Dec;19(12):1228-1239 [FREE Full text] [doi: 10.1111/j.1525-1497.2004.40153.x] [Medline: 15610334]
3. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Viera A, Crotty K. Health literacy interventions and outcomes: an updated systematic review. Rockville, MD: Agency for Healthcare Research and Quality; 2011. Evidence report/technology assessment no. 199 URL: https://www.ahrq.gov/downloads/pub/evidence/pdf/literacy/literacyup.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIEBYNMH]
4. Berkman ND, Dewalt DA, Pignone MP, Sheridan SL, Lohr KN, Lux L, et al. Literacy and health outcomes. Evid Rep Technol Assess (Summ) 2004 Jan(87):1-8. [Medline: 15819598]
5. Baker DW, Wolf MS, Feinglass J, Thompson JA, Gazmararian JA, Huang J. Health literacy and mortality among elderly persons. Arch Intern Med 2007 Jul 23;167(14):1503-1509. [doi: 10.1001/archinte.167.14.1503] [Medline: 17646604]
6. Sudore RL, Yaffe K, Satterfield S, Harris TB, Mehta KM, Simonsick EM, et al. Limited literacy and mortality in the elderly: the health, aging, and body composition study. J Gen Intern Med 2006 Aug;21(8):806-812 [FREE Full text] [doi: 10.1111/j.1525-1497.2006.00539.x] [Medline: 16881938]
7. Beebe CA, Schmitt S. Engaging patients in education for self-management in an accountable care environment. Clin Diabetes 2011 Aug 05;29(3):123-126. [doi: 10.2337/diaclin.29.3.123]
8. Pignone M, DeWalt DA, Sheridan S, Berkman N, Lohr KN. Interventions to improve health outcomes for patients with low literacy. A systematic review. J Gen Intern Med 2005 Feb;20(2):185-192 [FREE Full text] [doi: 10.1111/j.1525-1497.2005.40208.x] [Medline: 15836553]
9. Osborn CY, Cavanaugh K, Wallston KA, Kripalani S, Elasy TA, Rothman RL, et al. Health literacy explains racial disparities in diabetes medication adherence. J Health Commun 2011;16 Suppl 3:268-278 [FREE Full text] [doi: 10.1080/10810730.2011.604388] [Medline: 21951257]
10. Osborn CY, Cavanaugh K, Wallston KA, White RO, Rothman RL. Diabetes numeracy: an overlooked factor in understanding racial disparities in glycemic control. Diabetes Care 2009 Sep;32(9):1614-1619 [FREE Full text] [doi: 10.2337/dc09-0425] [Medline: 19401443]
11. Osborn CY, Paasche-Orlow MK, Bailey SC, Wolf MS. The mechanisms linking health literacy to behavior and health status. Am J Health Behav 2011;35(1):118-128 [FREE Full text] [Medline: 20950164]
12. Waldrop-Valverde D, Osborn CY, Rodriguez A, Rothman RL, Kumar M, Jones DL. Numeracy skills explain racial differences in HIV medication management. AIDS Behav 2010 Aug;14(4):799-806 [FREE Full text] [doi: 10.1007/s10461-009-9604-4] [Medline: 19669403]
13. Smedley BD, Stith AY, Nelson AR. Unequal treatment: confronting racial and ethnic disparities in health care. Washinton, DC: National Academies Press; 2003.
14. Diez Roux AV. Conceptual approaches to the study of health disparities. Annu Rev Public Health 2012 Apr;33:41-58 [FREE Full text] [doi: 10.1146/annurev-publhealth-031811-124534] [Medline: 22224879]
15. Franks P, Fiscella K. Reducing disparities downstream: prospects and challenges. J Gen Intern Med 2008 May;23(5):672-677 [FREE Full text] [doi: 10.1007/s11606-008-0509-0] [Medline: 18214626]
16. Woolf SH, Chan EC, Harris R, Sheridan SL, Braddock CH, Kaplan RM, et al. Promoting informed choice: transforming health care to dispense knowledge for decision making. Ann Intern Med 2005 Aug 16;143(4):293-300. [Medline: 16103473]
17. Pearson ML, Mattke S, Shaw R, Ridgely MS, Wiseman SH. Patient self-management support programs: an evaluation. Rockville, MD: Agency for Healthcare Research and Quality; 2007. Final contract report (Prepared by RAND Health)

URL: https://www.ahrq.gov/sites/default/files/publications/files/ptmgmt.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIEcdq9d]
18. US Department of Health and Human Services. National healthcare disparities report 2011 (AHRQ Publication No. 12-0006). Rockville, MD: US Department of Health and Human Services, Agency for Healthcare Research and Quality; 2012. URL: http://www.integration.samhsa.gov/workforce/National_Healthcare_Disparities_Report.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIFwwVjN]
19. Committee on the Future Health Care Workforce for Older Americans. Retooling for an aging America: building the healthcare workforce. Washington DC: National Academies Press; 2008.
20. Oshima LE, Emanuel EJ. Shared decision making to improve care and reduce costs. N Engl J Med 2013 Jan 03;368(1):6-8. [doi: 10.1056/NEJMp1209500] [Medline: 23281971]
21. Ory MG, Ahn S, Jiang L, Smith ML, Ritter PL, Whitelaw N, et al. Successes of a national study of the Chronic Disease Self-Management Program: meeting the triple aim of health care reform. Med Care 2013 Nov;51(11):992-998. [doi: 10.1097/MLR.0b013e3182a95dd1] [Medline: 24113813]
22. Jaglal SB, Guilcher SJ, Hawker G, Lou W, Salbach NM, Manno M, et al. Impact of a chronic disease self-management program on health care utilization in rural communities: a retrospective cohort study using linked administrative data. BMC Health Serv Res 2014;14(1):198 [FREE Full text] [doi: 10.1186/1472-6963-14-198] [Medline: 24885135]
23. Newman S, Steed L, Mulligan K. Self-management interventions for chronic illness. Lancet 2004;364(9444):1523-1537. [doi: 10.1016/S0140-6736(04)17277-2] [Medline: 15500899]
24. Melchior MA, Seff LR, Bastida E, Albatineh AN, Page TF, Palmer RC. Intermediate outcomes of a chronic disease self-management program for Spanish-speaking older adults in South Florida, 2008-2010. Prev Chronic Dis 2013 Aug 29;10:E146 [FREE Full text] [doi: 10.5888/pcd10.130016] [Medline: 23987252]
25. Ownby RL, Acevedo A, Waldrop-Valverde D, Jacobs RJ, Caballero J, Davenport R, et al. Development and initial validation of a computer-administered health literacy assessment in Spanish and English: FLIGHT/VIDAS. Patient Relat Outcome Meas 2013;4:21-35 [FREE Full text] [doi: 10.2147/PROM.S48384] [Medline: 23990736]
26. Ownby RL, Acevedo A, Waldrop-Valverde D, Jacobs RJ, Caballero J. Abilities, skills and knowledge in measures of health literacy. Patient Educ Couns 2014 May;95(2):211-217 [FREE Full text] [doi: 10.1016/j.pec.2014.02.002] [Medline: 24637163]
27. Ownby RL, Acevedo A, Jacobs RJ, Caballero J, Waldrop-Valverde D. Quality of life, health status, and health service utilization related to a new measure of health literacy: FLIGHT/VIDAS. Patient Educ Couns 2014;96(3):404-410 [FREE Full text] [doi: 10.1016/j.pec.2014.05.005] [Medline: 24856447]
28. Ownby RL, Waldrop-Valverde D, Jacobs RJ, Acevedo A, Caballero J. Cost effectiveness of a computer-delivered intervention to improve HIV medication adherence. BMC Med Inform Decis Mak 2013;13:29 [FREE Full text] [doi: 10.1186/1472-6947-13-29] [Medline: 23446180]
29. Ownby RL, Waldrop-Valverde D, Caballero J, Jacobs RL. Baseline medication adherence and response to an electronically delivered health literacy intervention targeting adherence. Neurobehav HIV Med 2012;4:113-121 [FREE Full text] [doi: 10.2147/NBHIV.S36549] [Medline: 23293544]
30. Ownby RL, Jacobs RJ, Waldrop-Valverde D, Davenport R, Caballero J. A computer-delivered IMB-based health literacy intervention reduces racial disparities in HIV information. 2013 Presented at: The annual adherence meeting of the International Association of Providers in AIDS Care; 2013; Miami URL: http://www.iapac.org/AdherenceConference/presentations/ADH8_OA121.pdf
31. Harman JJ, Amico KR, Johnson BT. Standard of care: promoting antiretroviral adherence in clinical care. AIDS Care 2005;17(2):237-251. [doi: 10.1080/09540120512331325707] [Medline: 15763717]
32. Kessels RP. Patients' memory for medical information. J R Soc Med 2003 May;96(5):219-222 [FREE Full text] [Medline: 12724430]
33. Kravitz RL, Hays RD, Sherbourne CD, DiMatteo MR, Rogers WH, Ordway L, et al. Recall of recommendations and adherence to advice among patients with chronic medical conditions. Arch Intern Med 1993;153(16):1869-1878. [Medline: 8250648]
34. Tarn DM, Heritage J, Paterniti DA, Hays RD, Kravitz RL, Wenger NS. Physician communication when prescribing new medications. Arch Intern Med 2006;166(17):1855-1862. [doi: 10.1001/archinte.166.17.1855] [Medline: 17000942]
35. Sheridan SL, Halpern DJ, Viera AJ, Berkman ND, Donahue KE, Crotty K. Interventions for individuals with low health literacy: a systematic review. J Health Commun 2011;16 Suppl 3:30-54. [doi: 10.1080/10810730.2011.604391] [Medline: 21951242]
36. D'Eath M, Barry MM, Sixsmith J. A rapid evidence review of interventions for improving health literacy. Stockholm: European Centre for Disease Prevention and Control; 2012. URL: http://ecdc.europa.eu/en/publications/Publications/1205-TER-Improving-Health-Literacy.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIMTx8AO]
37. Hibbard JH, Greene J, Tusler M. Improving the outcomes of disease management by tailoring care to the patient's level of activation. Am J Manag Care 2009;15(6):353-360 [FREE Full text] [Medline: 19514801]

38. Ownby RL, Hertzog C, Czaja SJ. Tailored information and automated reminding to improve medication adherence in Spanish- and English-speaking elders treated for memory impairment. Clin Gerontol 2012;35(3):221-238 [FREE Full text] [doi: 10.1080/07317115.2012.657294] [Medline: 24244067]
39. Lustria ML, Cortese J, Noar SM, Glueckauf RL. Computer-tailored health interventions delivered over the Web: review and analysis of key components. Patient Educ Couns 2009;74(2):156-173. [doi: 10.1016/j.pec.2008.08.023] [Medline: 18947966]
40. Campbell MK, Quintiliani LM. Tailored interventions in public health: where does tailoring fit in interventions to reduce health disparities? Am Behav Sci 2006 Feb 01;49(6):775-793. [doi: 10.1177/0002764205283807]
41. Hawkins RP, Kreuter M, Resnicow K, Fishbein M, Dijkstra A. Understanding tailoring in communicating about health. Health Educ Res 2008;23(3):454-466 [FREE Full text] [doi: 10.1093/her/cyn004] [Medline: 18349033]
42. Noar SM, Benac C, Harris M. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychol Bull 2007;133(4):673-693. [doi: 10.1037/0033-2909.133.4.673] [Medline: 17592961]
43. Jerant A, Sohler N, Fiscella K, Franks B, Franks P. Tailored interactive multimedia computer programs to reduce health disparities: opportunities and challenges. Patient Educ Couns 2011;85(2):323-330 [FREE Full text] [doi: 10.1016/j.pec.2010.11.012] [Medline: 21146950]
44. Jerant A, Kravitz RL, Fiscella K, Sohler N, Romero RL, Parnes B, et al. Effects of tailored knowledge enhancement on colorectal cancer screening preference across ethnic and language groups. Patient Educ Couns 2013;90(1):103-110 [FREE Full text] [doi: 10.1016/j.pec.2012.08.017] [Medline: 22985627]
45. McDaniel AM, Casper GR, Hutchison SK, Stratton RM. Design and testing of an interactive smoking cessation intervention for inner-city women. Health Educ Res 2005;20(3):379-384 [FREE Full text] [doi: 10.1093/her/cyg135] [Medline: 15522897]
46. Kreuter MW. Integrating culture into health information for African American women. Am Behav Sci 2006;49(6):794-811. [doi: 10.1177/0002764205283801]
47. Shaw B, Gustafson DH, Hawkins R, McTavish F, McDowell H, Pingree S, et al. How underserved breast cancer patient use and benefit from eHealth programs: implications for closing the digital divide. Am Behav Sci 2006;49(6):823-834. [doi: 10.1177/0002764205283803]
48. Pekmezi DW, Neighbors CJ, Lee CS, Gans KM, Bock BC, Morrow KM, et al. A culturally adapted physical activity intervention for Latinas. Am J Prev Med 2009;37(6):495-500. [doi: 10.1016/j.amepre.2009.08.023]
49. Rudd RE, Moeykens FA, Colton TC. Health and literacy: a review of medical and public health literature. In: Review of Adult Learning and Literacy. Boston, MA: National Center for the Study of Adult Learning and Literacy; 1999.
50. United States Department of Health and Human Services. America's health literacy: why we need accessible health information. Washington DC: United States Department of Health and Human Services, Office of Disease Prevention and Health Promotion; 2013. URL: https://health.gov/communication/literacy/issuebrief/ [accessed 2017-01-05] [WebCite Cache ID 6nIOtbRon]
51. United States Department of Health and Human Services. Improving health literacy for older adults. Expert panel report. Atlanta GA: United States Department of Health and Human Services, Centers for Disease Control; 2013. URL: https://www.cdc.gov/healthliteracy/pdf/olderadults.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIP10U0C]
52. Brouwer W, Oenema A, Crutzen R, de Nooijer J, de Vries NI, Brug J. An exploration of factors related to dissemination of and exposure to internet-delivered behavior change interventions aimed at adults: a Delphi study approach. J Med Internet Res 2008 Apr 16;10(2):e10 [FREE Full text] [doi: 10.2196/jmir.956] [Medline: 18417443]
53. Francis L, Weiss BD, Senf JH, Heist K, Hargraves R. Does literacy education improve symptoms of depression and self-efficacy in individuals with low literacy and depressive symptoms? A preliminary investigation. J Am Board Fam Med 2007;20(1):23-27 [FREE Full text] [doi: 10.3122/jabfm.2007.01.060058] [Medline: 17204731]
54. Hibbard JH, Mahoney ER, Stock R, Tusler M. Do increases in patient activation result in improved self-management behaviors? Health Serv Res 2007 Aug;42(4):1443-1463 [FREE Full text] [doi: 10.1111/j.1475-6773.2006.00669.x] [Medline: 17610432]
55. Lorig KR, Ritter P, Stewart AL, Sobel DS, Brown FW, Bandura A, et al. Chronic disease self-management program: 2-year health status and health care utilization outcomes. Med Care 2001;39(11):1217-1223. [Medline: 11606875]
56. Lorig K, Holman H, Sobel D, Laurent D, Gonzalez V, Minor M. Living a healthy life with chronic conditions: self-management of heart disease, arthritis, diabetes, depression, asthma, bronchitis, emphysema, and other physical and mental health conditions. Boulder, CO: Bull Pub. Co; 2012.
57. Ownby RL, Waldrop-Valverde D, Hardigan P, Caballero J, Jacobs RJ, Acevedo A. Development and validation of a brief computer-administered HIV-related health literacy scale (HIV-HL). AIDS Behav 2013;17(2):710-718 [FREE Full text] [doi: 10.1007/s10461-012-0301-3] [Medline: 22961499]
58. Patton MQ. Qualitative research & evaluation methods: integrating theory and practice (4th ed). Thousand Oaks, Calif: Sage Publications; 2014.
59. Ehde DM, Dillworth TM, Turner JA. Cognitive-behavioral therapy for individuals with chronic pain: efficacy, innovations, and directions for research. Am Psychol 2014;69(2):153-166. [doi: 10.1037/a0035747] [Medline: 24547801]

60. Goyal M, Singh S, Sibinga EM, Gould NF, Rowland-Seymour A, Sharma R, et al. Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. JAMA Intern Med 2014 Mar;174(3):357-368 [FREE Full text] [doi: 10.1001/jamainternmed.2013.13018] [Medline: 24395196]
61. Martell CR, Dimidjian S, Herman-Dunn R. Behavioral activation for depression: a clinician's guide. New York: Guilford; 2010.
62. Cuijpers P, Donker T, Johansson R, Mohr DC, van Straten A, Andersson G. Self-guided psychological treatment for depressive symptoms: a meta-analysis. PLoS One 2011;6(6):e21274 [FREE Full text] [doi: 10.1371/journal.pone.0021274] [Medline: 21712998]
63. Jernelöv S, Lekander M, Blom K, Rydh S, Ljótsson B, Axelsson J, et al. Efficacy of a behavioral self-help treatment with or without therapist guidance for co-morbid and primary insomnia--a randomized controlled trial. BMC Psychiatry 2012 Jan 22;12:5 [FREE Full text] [doi: 10.1186/1471-244X-12-5] [Medline: 22264332]
64. Doak CC, Doak LG, Root JH. Teaching patients with low literacy skills, 2nd ed. Philadelphia: Lippincott; 1996. URL: https://www.hsph.harvard.edu/healthliteracy/resources/teaching-patients-with-low-literacy-skills/ [accessed 2017-01-05] [WebCite Cache ID 6nIPsLPzt]
65. Soricone L, Rudd R, Santos M, Capistrant B. Health literacy in adult basic education. Boston, MA: Health and Adult Literacy and Learning Initiative, Harvard School of Public Health; 2007. URL: https://cdn1.sph.harvard.edu/wp-content/uploads/sites/135/2012/09/healthliteracyinadulteducation.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIQBDPne]
66. Kirsch I. The International Adult Literacy Survey (IALS): Understanding what was measured. Princeton, NJ: Educational Testing Service; 2001. URL: https://www.ets.org/Media/Research/pdf/RR-01-25-Kirsch.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIQHuBrj]
67. Kruidenier JR, MacArthur CA, Wrigley HS. Adult education literacy instruction: a review of the research. Washington, DC: National Institute for Literacy; 2010. URL: https://lincs.ed.gov/publications/pdf/adult_ed_2010.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIQN1pTw]
68. Hibbard JH, Jewett JJ, Engelmann S, Tusler M. Can Medicare beneficiaries make informed choices? Health Aff (Millwood) 1998;17(6):181-193 [FREE Full text] [Medline: 9916368]
69. Apter AJ, Paasche-Orlow MK, Remillard JT, Bennett IM, Ben-Joseph EP, Batista RM, et al. Numeracy and communication with patients: they are counting on us. J Gen Intern Med 2008;23(12):2117-2124 [FREE Full text] [doi: 10.1007/s11606-008-0803-x] [Medline: 18830764]
70. Mayer RE, Moreno R. Nine ways to reduce cognitive load in multimedia learning. Educ Psychol 2003 Mar;38(1):43-52. [doi: 10.1207/S15326985EP3801_6]
71. Paas F, Renkl A, Sweller J. Cognitive Load Theory: instructional implications of the interaction between information structures and cognitive architecture. Instr Sci 2004;32(1/2):1-8. [doi: 10.1023/B:TRUC.0000021806.17516.d0]
72. Levinthal BR, Morrow DG, Tu W, Wu J, Murray MD. Cognition and health literacy in patients with hypertension. J Gen Intern Med 2008;23(8):1172-1176 [FREE Full text] [doi: 10.1007/s11606-008-0612-2] [Medline: 18459011]
73. Flesch R. A new readability yardstick. J Appl Psychol 1948;32(3):221-233. [Medline: 18867058]
74. Fernández Huerta J. Influencias del nivel académico de un texto y el lugar de origen de un lector en la comprensión de lectura de mensajesde comunicación en salud.: Observatorio Journal; 1959. Medidas sencillas de lecturabilidad URL: http://obs.obercom.pt/index.php/obs/article/download/232/253 [accessed 2017-01-05] [WebCite Cache ID 6nIdgJZJT]
75. Acevedo A, Krueger KR, Navarro E, Ortiz F, Manly JJ, Padilla-Vélez MM, et al. The Spanish translation and adaptation of the Uniform Data Set of the National Institute on Aging Alzheimer's Disease Centers. Alzheimer Dis Assoc Disord 2009;23(2):102-109 [FREE Full text] [doi: 10.1097/WAD.0b013e318193e376] [Medline: 19474568]
76. Barnum CM, Dragga S. Usability testing and research. New York: Allyn & Bacon; 2001.
77. Genov A. Journal of Usability Studies. 2005. Iterative usability testing as continuous feedback: a control systems perspective URL: http://uxpajournal.org/wp-content/uploads/pdf/JUS_Genov_Nov2005.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIQrHuZS]
78. Wiklund MD, Kendler J, Strochlic AY. Usability testing of medical devices. Boca Raton, FL: CRC Press; 2010.
79. Salvendy G, Smith MW, editors. Usability engineering at a discount. In: Designing and using human-computer interfaces and knowledge based systems: proceedings of the third International Conference on Human-Computer Interaction, Boston, Massachusetts, September 18-22, 1989, volume II. Amsterdam: Elsevier; Sep 07, 1989.
80. Nielsen J, Landauer TK. A mathematical model of the finding of usability problems. 1993 Presented at: CHI '93 Proceedings of the INTERACT '93 and CHI '93 conference on human factors in computing systems; 1993; Amsterdam p. 206-213 URL: https://www.interaction-design.org/literature/conference/proceedings-of-the-acm-chi-93-human-factors-in-computing-systems-conference
81. Zickuhr K, Madden M. Older adults and internet use. Washington, DC: Pew Research Center's Internet & American Life Project; 2012. URL: http://www.pewinternet.org/files/old-media/Files/Reports/2012/PIP_Older_adults_and_internet_use.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIfWbeWa]
82. Culén AL, Bratteteig T. Touch-screens and elderly users: a perfect match? 2013 Presented at: The Sixth International Conference on Advances in Computer-Human Interaction; 2013; Nice, France URL: https://www.thinkmind.org/download.php?articleid=achi_2013_18_30_20414

83. Jayroe TJ, Wolfram D. Internet searching, tablet technology and older adults. Baltimore, MD; 2012 Presented at: Association for Information Science and Technology; Oct 26-31, 2012; Baltimore, MD URL: https://www.asis.org/asist2012/proceedings/Submissions/236.pdf
84. Alvseike H, Brønnick K. Feasibility of the iPad as a hub for smart house technology in the elderly: effects of cognition, self-efficacy, and technology experience. J Multidiscip Healthc 2012;5:299-306 [FREE Full text] [doi: 10.2147/JMDH.S35344] [Medline: 23226024]
85. Murphy PW, Davis TC, Long SW, Jackson RH, Decker BC. Rapid Estimate of Adult Literacy in Medicine (REALM): a quick reading test for patients. J Read 1993;37:124-130 [FREE Full text]
86. Lee SY, Bender DE, Ruiz RE, Cho YI. Development of an easy-to-use Spanish health literacy test. Health Serv Res 2006;41(4 Pt 1):1392-1412 [FREE Full text] [doi: 10.1111/j.1475-6773.2006.00532.x] [Medline: 16899014]
87. Kirsch IS, Jungeblut A, Jenkins L, Kolstad A. Adult literacy in America: a first look at the findings of the National Adult Literacy Survey. Washington, DC: National Center for Educational Statistics; 2002. URL: https://nces.ed.gov/pubs93/93275.pdf [accessed 2017-01-05] [WebCite Cache ID 6nIfvWrJF]
88. Donahue PL, Daane MC, Grigg WS. Education Statistics Quarterly. 2013. The nation's report card: reading highlights 2003 URL: https://nces.ed.gov/programs/quarterly/Vol_5/5_4/3_3.asp#2 [accessed 2017-01-05] [WebCite Cache ID 6nIg371CT]
89. Hauser RM, Edley CF, Koenig JA, Elliott SW. Measuring literacy: performance levels for adults. Washington, DC: National Academies Press; 2015.
90. Groll DL, To T, Bombardier C, Wright JG. The development of a comorbidity index with physical function as the outcome. J Clin Epidemiol 2005;58(6):595-602. [doi: 10.1016/j.jclinepi.2004.10.018] [Medline: 15878473]
91. Lee SY, Stucky BD, Lee JY, Rozier RG, Bender DE. Short Assessment of Health Literacy-Spanish and English: a comparable test of health literacy for Spanish and English speakers. Health Serv Res 2010;45(4):1105-1120 [FREE Full text] [doi: 10.1111/j.1475-6773.2010.01119.x] [Medline: 20500222]
92. Robin X, Turck N, Hainard A, Tiberti N, Lisacek F, Sanchez J, et al. pROC: an open-source package for R and S+ to analyze and compare ROC curves. BMC Bioinformatics 2011;12:77 [FREE Full text] [doi: 10.1186/1471-2105-12-77] [Medline: 21414208]
93. White S, Dillow S. Key concepts and features of the 2003 National Assessment of Adult Literacy (NCES 2006-471). Washington, DC: US Department of Education, National Center for Educational Statistics; 2005. URL: http://files.eric.ed.gov/fulltext/ED489067.pdf [accessed 2017-01-06] [WebCite Cache ID 6nIh5mDo1]
94. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009;42(2):377-381 [FREE Full text] [doi: 10.1016/j.jbi.2008.08.010] [Medline: 18929686]
95. Ware JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992;30(6):473-483. [Medline: 1593914]
96. Lorig K, Stewart A, Ritter P, Gonzalez VM, Laurent D, Lynch J. Outcome measures for health education and other health care interventions. Thousand Oaks, CA: Sage Publications; 1996.
97. Hibbard JH, Stockard J, Mahoney ER, Tusler M. Development of the Patient Activation Measure (PAM): conceptualizing and measuring activation in patients and consumers. Health Serv Res 2004;39(4 Pt 1):1005-1026 [FREE Full text] [doi: 10.1111/j.1475-6773.2004.00269.x] [Medline: 15230939]
98. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. Appl Psychol Meas 1977 Jun 01;1(3):385-401 [FREE Full text] [doi: 10.1177/014662167700100306]
99. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983;24(4):385-396. [Medline: 6668417]
100. Bodenlos JS, Grothe KB, Kendra K, Whitehead D, Copeland AL, Brantley PJ. Attitudes toward HIV Health Care Providers scale: development and validation. AIDS Patient Care STDS 2004;18(12):714-720. [doi: 10.1089/apc.2004.18.714] [Medline: 15659882]
101. Wallston KA, Wallston BS, DeVellis R. Development of the Multidimensional Health Locus of Control (MHLC) scales. Health Educ Monogr 1978;6(2):160-170. [Medline: 689890]
102. Ryff CD, Lachman ME. National survey of Midlife Development in the United States (MIDUS II): Cognitive Project, 2004-2006. Ann Arbor, MI: Inter-university Consortium for Political and Social Research (ICPSR); 2013.
103. Peel NM, Kuys SS, Klein K. Gait speed as a measure in geriatric assessment in clinical settings: a systematic review. J Gerontol A Biol Sci Med Sci 2013;68(1):39-46. [doi: 10.1093/gerona/gls174] [Medline: 22923430]
104. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. JAMA 2013;309(1):71-82 [FREE Full text] [doi: 10.1001/jama.2012.113905] [Medline: 23280227]
105. Cameron AJ, Magliano DJ, Söderberg S. A systematic review of the impact of including both waist and hip circumference in risk models for cardiovascular diseases, diabetes and mortality. Obes Rev 2013;14(1):86-94. [doi: 10.1111/j.1467-789X.2012.01051.x] [Medline: 23072327]
106. Baker DW, Wolf MS, Feinglass J, Thompson JA. Health literacy, cognitive abilities, and mortality among elderly persons. J Gen Intern Med 2008 Jun;23(6):723-726 [FREE Full text] [doi: 10.1007/s11606-008-0566-4] [Medline: 18330654]

107. Bostock S, Steptoe A. Association between low functional health literacy and mortality in older adults: longitudinal cohort study. BMJ 2012;344:e1602 [FREE Full text] [Medline: 22422872]
108. Collaborative Institutional Training Initiative. 2017. URL: https://about.citiprogram.org/en/homepage/ [accessed 2017-04-01] [WebCite Cache ID 6pPEelB2F]
109. Graham JW. Missing data analysis: making it work in the real world. Annu Rev Psychol 2009;60:549-576. [doi: 10.1146/annurev.psych.58.110405.085530] [Medline: 18652544]
110. Enders CK, Bandalos DL. Structural Equation Modeling. 2014. The relative performance of full information maximum likelihood estimation for missing data in structural equation models URL: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1065&context=edpsychpapers [accessed 2017-01-05] [WebCite Cache ID 6nIi2oaKm]
111. Hedeker D, Gibbons RD. Application of random-effects pattern-mixture models for missing data in longitudinal studies. Psychol Methods 1997;2(1):64-78. [doi: 10.1037/1082-989X.2.1.64]

Abbreviations

ACASI: Automated Computer-Assisted Self-Interview
ASK: Abilities-Skills-Knowledge
AUC: area under the curve
CDSM: chronic disease self-management
FLIGHT/VIDAS: Fostering Literacy for Good Health Today/Vive Desarollando Amplia Salud
HIV: human immunodeficiency virus
HL: FLIGHT/VIDAS Health Literacy scale
IRB: Institutional Review Board
MAR: missing at random
NUM: FLIGHT/VIDAS Numeracy scale
QDS: Questionnaire Development System
REALM: Rapid Estimate of Adult Literacy in Medicine
REDCap: Research Electronic Data Capture software
SAHLSA: Short Assessment of Health Literacy in Spanish Speaking Adults
SF-36: Medical Outcomes Study 36-item Short Form

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Protocol

HomeStyles, A Web-Based Childhood Obesity Prevention Program for Families With Preschool Children: Protocol for a Randomized Controlled Trial

Carol Byrd-Bredbenner[1*], PhD, RD; Jennifer Martin-Biggers[1*], PhD, RD; Mallory Koenings[1*], PhD, RD; Virginia Quick[1*], PhD, RD; Nobuko Hongu[2*], PhD, RD, MEd; John Worobey[1*], PhD

[1]Rutgers University, Department of Nutritional Sciences, New Brunswick, NJ, United States

[2]University of Arizona, Department of Nutritional Sciences, Tucson, AZ, United States

[*]all authors contributed equally

Corresponding Author:
Virginia Quick, PhD, RD
Rutgers University
Department of Nutritional Sciences
26 Nichol Avenue
New Brunswick, NJ, 08901
United States
Phone: 1 848 932 0965
Fax: 1 732 932 6522
Email: gingermquick@gmail.com

Abstract

Background: The home environment is where young children spend most of their time, and is critically important to supporting behaviors that promote health and prevent obesity. However, the home environment and lifestyle patterns remain understudied, and few interventions have investigated parent-led makeovers designed to create home environments that are supportive of optimal child health and healthy child weights.

Objective: The aim of the HomeStyles randomized controlled trial (RCT) is to determine whether the Web-based HomeStyles intervention enables and motivates parents to shape the weight-related aspects of their home environments and lifestyle behavioral practices (diet, exercise, and sleep) to be more supportive of their preschool children's optimal health and weight.

Methods: A rigorous RCT utilizing an experimental group and an attention control group, receiving a bona fide contemporaneous treatment equal in nonspecific treatment effects and differing only in subject matter content, will test the effect of HomeStyles on a diverse sample of families with preschool children. This intervention is based on social cognitive theory and uses a social ecological framework, and will assess: intrapersonal characteristics (dietary intake, physical activity level, and sleep) of parents and children; family interpersonal or social characteristics related to diet, physical activity, media use, and parental values and self-efficacy for obesity-preventive practices; and home environment food availability, physical activity space and supports in and near the home, and media availability and controls in the home.

Results: Enrollment for this study has been completed and statistical data analyses are currently underway.

Conclusions: This paper describes the HomeStyles intervention with regards to: rationale, the intervention's logic model, sample eligibility criteria and recruitment, experimental group and attention control intervention content, study design, instruments, data management, and planned analyses.

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KEYWORDS

childhood obesity; nutrition; physical activity; sleep; prevention; parents; children

Introduction

Evidence-based educational materials regarding obesity prevention for parents of preschool children remain scarce. The home environment is where young children spend most of their time and is critically important to supporting behaviors that promote health and prevent obesity. However, the home environment and lifestyle patterns remain understudied, and few interventions have investigated parent-led multifactorial makeovers designed to create home environments that are supportive of optimal child health and healthy child weights [1-7]. Results of studies indicate that home makeovers hold great promise for ameliorating childhood obesity [8-10]. Building upon previous work, HomeStyles was developed to help parents of young children shape or *makeover* (ie, change) their home environment and lifestyles to prevent childhood obesity. HomeStyles has two delivery modes: (1) independent online learning, and (2) in-home, face-to-face, individualized learning facilitated by trained home visitation staff. This paper reports the design and methods for the online delivery mode.

The HomeStyles project was funded by the National Institute of Food and Agriculture, United States Department of Agriculture (award number 2011-68001-30170). This project builds on the parent-directed home kitchen organization/food management makeover proof-of-concept *Shaping Up America's Kitchen* intervention that was successfully pilot tested with mothers of young children [9,10]. The pilot test findings supported the work of others indicating that teaching adults how to make home environment and lifestyle changes, like those proposed in this project, and building their self-efficacy can have a positive impact on their home environment and health [11-14]. Formative evaluation findings from *Shaping Up America's Kitchen* revealed that participants rated the intervention's materials highly (4-page *factivity* [facts + activity] folios) with regards to readability, completeness, relevance, and usefulness [10]. Pilot-test data showed that participant recruitment, retention, and satisfaction were excellent, and that participants significantly improved their health knowledge and self-efficacy [9].

The HomeStyles intervention is intended to enable and motivate parents of preschoolers to shape their home environment and lifestyle behavioral practices to create and support optimal child growth, health, and weights. The intervention is based on Social Cognitive Theory [5] and uses a social ecological framework [15]. HomeStyles targets the home because this environment plays a dominant role in the development of childhood eating and physical activity patterns, and these patterns track across the growing years into adulthood [16-18]. The program targets parents because they are children's role models, family food gatekeepers, and create the structure/lifestyle environment within the home, and thus strongly influence the obesity-prevention behaviors of children during the growing years [5,16-36]. In addition, parents need more opportunities to gain relevant, practical, nonjudgmental obesity prevention information that is easily implemented in their homes and hectic lifestyles [24]. HomeStyles uses a multifactorial approach because diet, physical activity, and sleep are well-known in the literature to be associated with childhood obesity risk, and the most successful results are likely to be generated by addressing multiple lifestyle practices in a family context [13,37-41]. An online delivery mode was selected because the vast majority of families in the United States have access to the Internet [42], it is a cost-effective delivery method, and it offers an excellent probability of contributing to the sustained availability of project materials after the study ends.

HomeStyles is innovative in that it is family-focused and based on parent-defined quality of life characteristics. Additionally, obesity prevention programs for young children continue to be limited and few obesity prevention programs for any age groups take a multifactorial approach that incorporates a broad array of factors associated with obesity risk that parents can address quickly, easily, and at low (or no) cost in the home environment. HomeStyles also focuses on the home environment, which is critically important to promoting health but remains sorely understudied. Finally, despite their promise for mitigating childhood obesity, few interventions have examined the efficacy of parent-led home environment restructuring that aims to shape these environments to be more supportive of optimal child health. Thus, the aim of the randomized controlled trial (RCT) is to determine whether the Web-based HomeStyles intervention enables and motivates parents in the experimental group to shape the weight-related aspects of their home environments and lifestyle behavioral practices (diet, exercise, and sleep) to be more supportive of their preschool children's optimal health and weight, compared to those in the control condition.

Methods

The study protocol involved two groups (experimental and attention control), and was approved by the institutional review boards at the authors' universities. All participants gave informed consent online before participating in any component of this study.

Logic Model

As shown in the HomeStyles logic model (Figure 1), the long-term outcome of HomeStyles is to improve health by preventing childhood obesity. To reach the long-term outcome, necessary inputs included: expertise from the project team, consultants, and advisory group; stakeholder involvement at all stages of the project; sufficient funding; equipment, facilities, and technological capacity to complete project development, implementation, and evaluation; partnerships with community leaders and organizations; and access to media to promote HomeStyles.

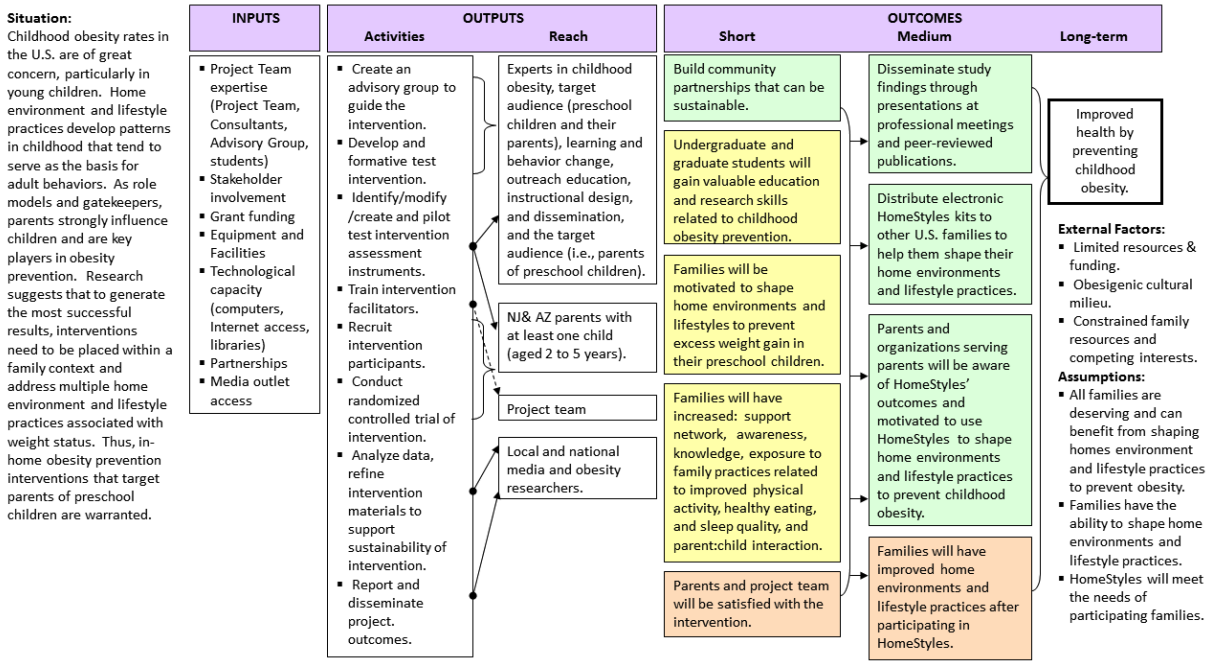
Eight main activities were needed to reach the project outcomes. The first was to create an advisory group comprised of experts in childhood obesity subject matter (eg, nutrition, exercise/fitness, sleep, child development), the target audience (eg, young children, pediatrics, parenting, social work, cultural competence), learning and behavior change (eg, psychology, behavioral scientists, motivational interviewing, adult learners), outreach education (eg, Cooperative Extension, informal education), instructional design (eg, education, graphic arts, computer technology), and research and outreach dissemination (eg, media, public relations). The second step was to develop

and formatively test the HomeStyles intervention, which engaged all experts and target audience members at every step; for details, see the *Intervention* section that follows. The third step was to select, adapt, or create intervention assessment instruments, which are also described in detail in the *Instruments* section. These instruments assess changes that occur while participating in the HomeStyles intervention. The fourth step was to train staff to facilitate the implementation of the intervention and RCT, which is critical to ensuring that all aspects of the intervention are conducted by project staff with uniformity and fidelity to the plan. Activities associated with the fifth step are described in the *Sample Eligibility and Recruitment* section that follows. The final steps were to conduct the RCT to assess the study aims, analyze RCT data, refine intervention materials to improve their quality and acceptability to the target audience, and report and disseminate the project outcomes.

These steps are expected to yield the short-term outcomes of: building sustainable community partnerships; training the next generation of health and nutrition professionals to develop and implement obesity prevention programs; enabling families to shape home environments and lifestyle practices to be preventative of childhood obesity; helping families develop the cognitions, behaviors, and relationships supportive of healthy child weights; and creating a childhood obesity prevention program that is satisfying to parents and those implementing the program. In the medium-term, project outcomes planned are to: disseminate RCT findings to professional groups, widely distribute HomeStyles materials to families, make parents and organizations serving parents aware of HomeStyles and promote its use and adoption, and improve families' home environments and lifestyle practices. These short- and medium-term outcomes will contribute to achieving the long-term societal outcome of improved health by preventing childhood obesity.

External factors affecting outcomes include: limits on resources and funding; the obesogenic nature of the prevailing culture in the United States; and resource (eg, time, energy, money) scarcity experienced by families, which may impede their progress. HomeStyles is based on the premises that all families are deserving of the opportunity to benefit from shaping home environments and lifestyle practices, all have the capacity to shape home environments and lifestyles, and that HomeStyles will meet their needs. Thus, efforts were made to include families from a variety of sociodemographic backgrounds and geographic locations during program creation and testing.

Figure 1. Logic Model for HomeStyles Online Intervention.



Sample Eligibility Criteria and Recruitment

To be eligible for the HomeStyles project, individuals required basic reading and writing skills (either English or Spanish) and had to be parents aged 20 to 45 years. Participants also had to be the household primary food gatekeeper, live in the catchment area (New Jersey and Arizona), have at least one young child (aged 2 to 5 years), and have regular Internet access.

Recruitment materials invited parents of preschool children to participate in a program designed to help them raise, "even happier, healthier, safer children" and directed them to a website to learn more and complete a screener to determine whether they met eligibility requirements. Recruitment materials (eg, printed flyers, posters, bookmarks, and brief videos) were posted to: email listservs of workplaces; philanthropic, religious, and community groups; preschool/day care centers; professional associations; and extracurricular activity/afterschool groups. These materials also were posted to websites (eg, online community newspapers, local businesses, parent blogs), distributed via social media (eg, Facebook, Pinterest), and included in a variety of media (eg, magazines, newspapers,

radio, and television). Community partners (eg, pediatric and dietetic associations, fitness centers, schools) as well as personal contacts (eg, colleagues, family, friends, neighbors) and a professional study recruitment company also distributed recruitment materials. In-person recruitment strategies included tabling activities at: community events; parent resource centers; Women, Infants, and Children program offices; and farmers' markets.

The goal of HomeStyles is obesity *prevention*. However, formative testing revealed that parents strongly disliked the term *obesity* and identified *happier, more closely bonded families* as the key component of a high quality of life and health. These findings drove the thrust and tone of the recruitment materials. Recruitment materials included a link to a webpage that described the study components and expectations, and invited parents to complete a brief questionnaire to determine eligibility.

Recruitment of participants occurred over a 15-month period. The rolling enrollment allowed families to enter at different times of the year, and gave project staff increased time and control over recruitment efforts, retention activities, and intervention management while also controlling staffing costs. All participants provided email, address, and phone contact information. The enrollment goal was 210 parents (with half in each study condition), based on an *a priori* power analysis for analysis of covariance (controlling for baseline scores) calculated with G*Power software version 3.1.9.2 (Universitat Kiel, Germany), which was set for 2 groups with a small effect size (0.25), *P*-value (alpha)=.05, and power (beta)=0.95. A recruitment goal of approximately 300 parents was established to allow for attrition.

Intervention Content

Experimental Group: Healthy HomeStyles

The HomeStyles experimental group intervention materials (Healthy HomeStyles) are described in detail elsewhere [43,44]. In brief, the materials were delivered via the Web and consisted of 12 instructional guides in the form of 4-page mini-magazines. The introductory guide provided an overview of the project and was designed to help parents select the other guides that would be most useful to their families. Each of the other 11 guides focused on one key nutrition, physical activity, or sleep message (Figure 2). All guides included ideas to help parents advocate to their child care providers for healthy nutrition, physical activity, and sleep (nap) practices because the vast majority of preschoolers spend at least some time in nonparental childcare settings. Children cared for at home by their parents are less likely to be obese than children cared for by others, suggesting a need for a larger parental role in the management of their children when they are away from home [45-49].

Figure 2. HomeStyles Key Messages.

Organization and Content of Intervention Materials

Each guide was organized similarly and content was created and ordered using motivational interviewing strategies [50,51]. The guide cover was a full-color photograph showing children alone or with parents engaging in an activity reflective of the guide content. Cover lines designed to capture parent attention were displayed on each cover [44,52]. The inside verso page briefly summarized the evidence-based research indicating why the guide's topic is important for good health, reminded parents that they are their children's most important role models, helped parents reflect on why the behaviors discussed in the guide are important to them personally using scaling (eg, "How important is this to you on a scale of 1 to 10? Why did you choose that number? What would have to be different for you to choose a higher number?"), and encouraged them to make simple changes to promote optimal child health. The inside recto page provided tips and ideas from other parents of preschoolers who previously participated in HomeStyles-related focus groups, offered more information on the guide's topic, gave parents another opportunity to consider why the behaviors promoted in the guide were important to them, and encouraged them to make simple changes. The back of the guide focused on goal setting and provided examples of goals that other parents set, and encouraged parents to think about goals that they could set for their families. The guide concluded with a brief summary and reminder to choose small, manageable changes that are important to their families. Full-color photographs and a variety of graphic elements (eg, shading, highlighting, font treatments) were used to enhance the visual appeal of the guides. Each guide took approximately 15 minutes to review.

Each guide focusing on a key message was accompanied by a goal tracking sheet that encouraged parents to set goals related to the guide, monitor progress toward goals, and reward their family for reaching goals [53]. Most key message guides were accompanied by enhancements (objects with instructions/ideas for use) that facilitated implementation of the promoted behaviors. Examples of enhancements included: measuring cups for the portion sizes guide, a cutting board for the fruits and vegetables guide, a family mealtime conversation idea fan deck for the family meals guides, colorful straws and recipe ideas for the beverage guide, hula hoops and beach balls for the physical activity guides, and timers for the taming television guide. Enhancements were mailed to participants.

A series of *gentle nudges* was created and cognitively tested for all guides [54]. Nudges are periodic, brief communications that provide social support to help individuals change their behaviors [55,56]. Nudges were designed to be delivered by phone, text messaging, and/or email, per participant preference. A password-protected website was constructed to: deliver the guides, goal trackers, and nudges; enable participants to see how they were progressing through the intervention; and provide additional information (eg, how to get the most out of participation, set goals, build self-confidence, and cope with stress).

Intervention Development Process

The development process used for all experimental group intervention materials ensured inclusion of components of effective health interventions. Namely, processes were based on current obesity prevention guidelines and up-to-date research literature, had a strong theoretical basis (ie, Social Cognitive Theory [5,57]), used participatory planning and implementation strategies (ie, stakeholder [parents of preschoolers] input, advisory group, Adult Learning Theory [58-63]), and conveyed clear messages to participants (ie, designed using the Attention, Relevance, Confidence, Satisfaction [ARCS] Model of Motivational Design [58,59]) that were delivered using motivational interviewing principles [50,51,64,65].

Key obesity prevention guidelines used to develop HomeStyles were from the Institute of Medicine, Centers for Disease Control and Prevention, White House Task Force, Dietary Guidelines for Americans, and Healthy People 2020 [24,66-69]. Extensive literature reviews were conducted to ensure the most salient home environment and lifestyle practices were targeted in the intervention, and to inform the content of the intervention materials [70,71].

Bandura's Social Cognitive Theory [57] provided the theoretical underpinnings for HomeStyles. This theory's concept of *reciprocal determinism* was well suited to HomeStyles in that it expresses the idea that environment, behaviors, and personal characteristics mutually and concurrently affect each other, and that humans have the capacity to form or transform environments to support desired behavioral outcomes [5]. The behavior change strategies employed in intervention materials that aimed to develop and support this capacity for change included: outcome expectations, attitudes and values, self-efficacy, collective (family) efficacy, vicarious observational learning (learning about how other parents achieved child weight-protective goals), barrier removal/support building, and self-regulation (ie, goal setting, self-reward, and enlisting social support) [5,72,73].

Numerous participatory planning and implementation strategies were employed to ensure HomeStyles intervention materials were responsive to the wants and needs of the target audience. For instance, parents of preschoolers were involved throughout the development, implementation, and evaluation of all aspects of the intervention. Before intervention material development began, 139 parents participated in focus groups to elucidate their quality-of-life determinates and weight-related behaviors, views, aspirations, and obstacles [74]. During intervention material development, 512 parents participated in cognitive testing interviews to verify that intervention material content was useful, attention-catching, clear, appealing, relevant, interesting, motivating, warm and understanding in tone, and *guilt-free* [43]. The advisory group was consulted regularly throughout all phases of the intervention to ensure that the most current knowledge and best practices were employed. Additionally, Adult Learning Theory guided HomeStyles development. This theory recognizes that effective instruction for adult learners involves them as equal partners, respects their knowledge-base and life experiences, clarifies the importance of the content, addresses their desire for relevant and worthwhile content, and promotes rapid application of knowledge to meet their goals [58-63].

ARCS and motivational interviewing were used in tandem with Adult Learning Theory. ARCS focuses on motivating learners by capturing their *attention*, providing *relevant* content, and targeting learner *confidence* and *satisfaction* [58,59]. Motivational interviewing is a client-centered, goal-oriented counseling strategy that facilitates behavior change by helping individuals clarify goals and aspirations, explore and resolve ambivalence to changing behavior, build self-efficacy for behavior change, stimulate intrinsic motivation to change behavior, and make plans to change [50,51,64,65]. Although originally developed for in-person counseling sessions, motivational interviewing strategies can be successfully used in self-instructional written materials [75].

Control Group: Safe HomeStyles

An attention control group was used to promote participant retention and control for nonspecific treatment effects (eg, participant burden, activity and data collection format, study event scheduling, attention from researchers). Thus, the control group received a bona fide treatment equal in nonspecific treatment effects to, and contemporaneously with, the experimental group [76,77]. A total of 12 intervention guides were designed for the control group. Figure 2 lists the topic of each guide. As in the experimental condition, an introductory guide was developed to provide an overview of the project to help parents select subsequent guides that would be of greatest value to their families. Content for the remaining guides (Safe HomeStyles) was derived from government-produced home safety [78] and food safety and handwashing [79-85] educational materials, and reformatted into 4-page mini-magazines to have a look and feel similar that of the experimental condition. Additionally, nudges were written, enhancements were

developed (eg, refrigerator thermometer, reminder magnets and wrist bands, lint-free dust cloths, stickers for labeling household poisons), and website content was created. Control group participants only had access to Safe HomeStyles materials on the website, whereas experimental group participants could only access the website material focused on Healthy HomeStyles.

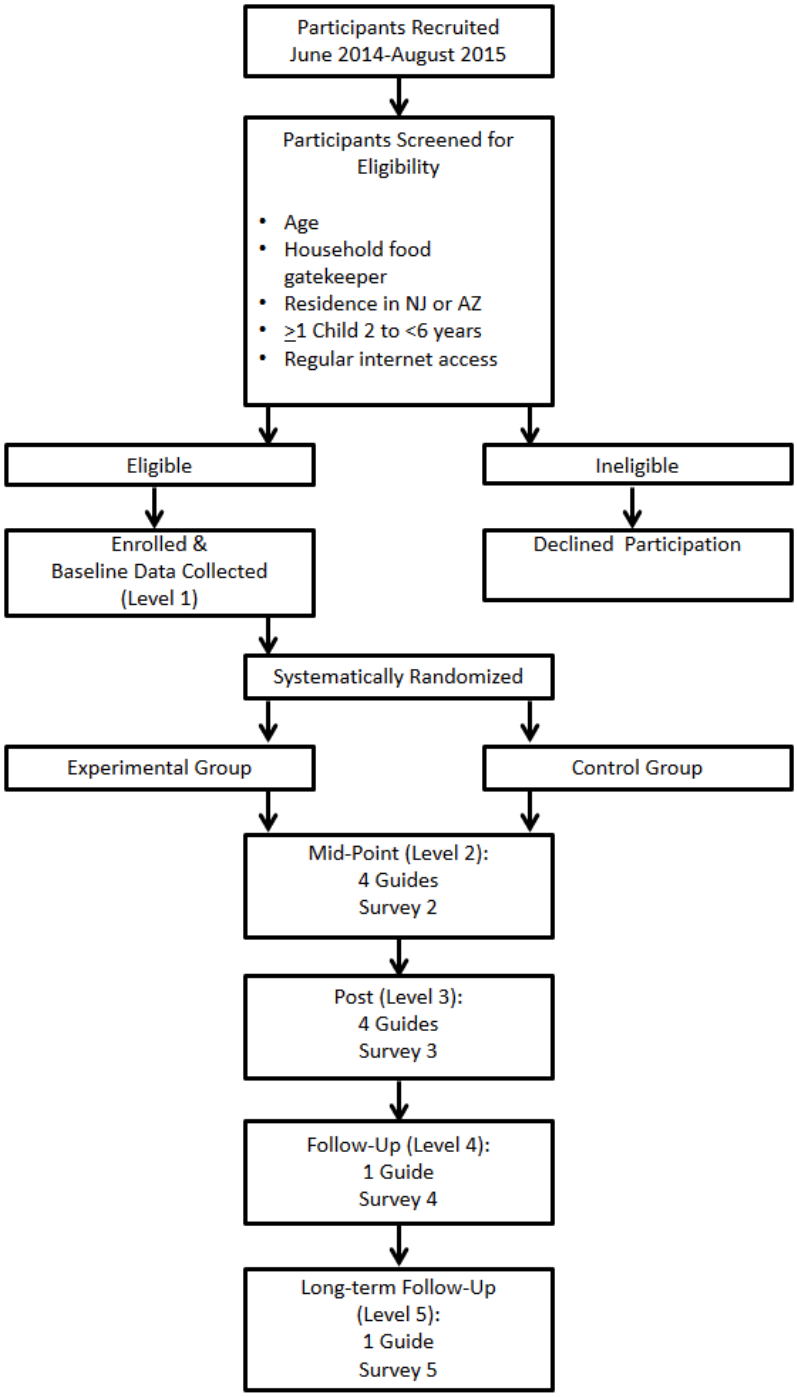
Randomized Controlled Trial Design

Figure 3 illustrates the flow of the intervention study based on CONSORT guidelines [86]. Recruited participants began by completing a brief eligibility screener survey. Those who were eligible began the first of five sequential levels of participation. Each subsequent level of the intervention commenced immediately after concluding the activities in the previous level. In Level 1, participants completed the baseline survey online, after which they were systematically randomized by computer into the control or experimental group. Recruitment materials and the bona fide treatment delivered to the attention control group format were designed to blind participant assignment to study condition. In Level 2, participants received the introductory guide and were then able to select a new guide approximately every 16 to 30 days. After a total of 4 guides in Level 2, participants completed the second (mid-point) survey. In Level 3, participants selected 4 additional guides, with a new guide approximately every 16 to 30 days, then completed the third (post) survey. In Level 4, participants selected one new guide or revisited a previously selected guide, per their choice, and approximately 30 to 60 days later they completed the fourth (follow-up) survey. Similarly, in Level 5, participants selected one new guide or revisited a previously selected guide and completed the fifth (long-term follow-up) survey approximately 30 to 60 days later. Completion of all levels was designed to take approximately 12 to 18 months. Levels 1 to 3 were the main components of the intervention; Levels 4 and 5 were designed to allow assessment of longer-term intervention effects.

After selecting a guide, parents were encouraged to: spend approximately 15 minutes reviewing it; think about changes like those suggested in the guide that could help their families; select one or two simple, quick, low-cost changes to implement in their homes for a few weeks; and then choose a new guide. After selecting a guide on the website, parents were sent a hard copy of the guide and, for at least every second guide selected, they were sent an enhancement that supported the guide. Participants received a nudge approximately 5 days after selecting a new guide, and then every 5 days for 30 days they received a new nudge; during this period, the first 4 nudges were guide-specific and the final 2 were reminders to visit the website to choose a new guide.

Project staff closely monitored participant progress throughout the study by observing their visits to the website. To minimize attrition, participants that were not progressing through the study in the expected time frame received friendly reminders (by phone and email) that encouraged them to return to the website to complete the next activity (choose new guide or complete a survey). In addition, bilingual project staff were trained in customer service and rapidly responded to participant queries coming in via email or the project's toll-free phone line using scripted responses to ensure similar and equal treatment across study groups. Participants also received modest, but increasing stipends after completing each survey. Other strategies to retain study participants included mailed enhancements, holiday cards, and opportunities to earn *bonus bucks* (an extra US $1) by visiting the website and answering a quick, fun question (eg, "Oprah's Calling! What should she know about HomeStyles?") that was refreshed approximately every 10 days [52].

Figure 3. HomeStyles intervention study flow based on CONSORT guidelines.



Instruments

Survey Development

Development of the study instruments began with an extensive literature search to identify the most salient sociodemographic characteristics and environmental, behavioral, and psychographic constructs that affect weight-related aspects of the home environment and lifestyle patterns. The literature review also served to identify valid, reliable, brief, and easy-to-administer self-report instruments suitable to the study purpose and target audience [87,88]. Furthermore, survey development involved a review of instruments that were previously developed by the HomeStyles researchers and used in analogous investigations [89]. When multiple scales for assessing a characteristic or construct were identified, a panel of nutrition experts in tests and measurements determined which was best suited to the study. For lengthy scales (ie, exceeding 6 items), published psychometric and factor analysis data were scrutinized to determine whether these scales could be shortened to reduce participant burden while preserving instrument integrity, validity, and reliability [90]. In the few cases where published psychometric data for lengthy scales could not be located, the panel of experts identified the most salient items.

When appropriate instruments could not be located, they were developed *de novo*. The process that was used to develop and refine scales followed Redding et al's sequential approach to measurement of health behavior change constructs [91]. If scales contained items that were heavily modified from their original form or developed *de novo*, five experts in subject matter areas appropriate to the scale content (eg, nutrition, physical activity, psychology, child development, obesogenic environment), psychometrics, and survey design reviewed them to ensure scale clarity and content validity (ie, items in the scale reflect the characteristic being measured) [92,93]. The scales were iteratively reviewed by experts and refined until all experts agreed on scale content and construction. These scales were then subjected to cognitive testing by participants with characteristics similar to the study population (but did not participate in the final study) to ascertain whether participants interpreted the items as intended, and allowed us to identify ways to reduce participant burden and increase acceptability [92,94-96]. During cognitive testing, participants read each item aloud and then stated in their own words what the item was asking, answered the item, and explained their answers. At the end of the cognitive interviews, participants answered open-ended questions to determine how the items could be refined to make them easier to understand and faster (less burdensome/more acceptable) to complete. Items underwent iterative refinement and cognitive testing until they were clearly understood by, and acceptable to, the target audience [91]. The Home Opportunities for Physical activity check-Up (HOP-Up) scale is an example of the application and outcome of this scale development process [97].

All survey items were assembled into an online survey (using Qualtrics) that was pretested with 48 individuals with characteristics like those eligible for the final study (but did not participate in the study) to identify refinements needed to improve clarity, layout, reading ease, and acceptability, and to verify accuracy of scale scoring algorithms. A pilot-test with 550 individuals like those in the pretest identified a small number of additional refinements and confirmed usability, internal consistency, scale unidimensionality, and participant satisfaction [98]. As a final check, the panel of experts again reviewed the survey and pilot-test outcomes and confirmed the measures' integrity and suitability to the study purpose.

Sociodemographic Appraisals

The survey included an array of sociodemographic assessments that permit the construction of a description of study participants. Data collected included parent age, sex, race/ethnicity, education level, and marital status as well as the *target* child's age and sex. Parents having more than one preschool child were instructed to report on the child born closest to noon on June 1 (*a priori* randomly selected time and date). Parents rated their own and their child's health status (poor, fair, good, very good, or excellent) using the Centers for Disease Control and Prevention's Health-Related Quality of Life questionnaire [99,100]. Hager et al's food insecurity screener was used to assess family food insecurity risk [101]. Family socioeconomic status was assessed with the 4-item Family Affluence Scale [102,103].

Outcome Measures

The outcome measures were organized according to the social ecological framework: individual (intrapersonal) assessments of parents and children, family/social interaction (interpersonal) evaluations, and home physical environment appraisals. As shown in Multimedia Appendix 1, primary outcome measures were home environment characteristics and lifestyle practices. Secondary outcome measures included parental behaviors, child behaviors, parental values, and self-efficacy for obesity preventive practices.

For items pertaining to children, parents were asked to answer them with their preschool children in mind. To keep parent attention directed to this *target* child, the child's name (or nickname) entered in the survey by the parent was automatically populated in survey items pertaining to the child. For instance, "In the past week, how many days did *Tommy* run, jump...", rather than "… how many days did *your child* run, jump…" Multimedia Appendix 1 organizes the outcome measures according to a social ecology framework and includes multiple details, including the number of items on scales, answer choice options and scoring, possible score range, references, and relationship to social cognitive theory constructs.

Individual measurements included height and weight data which were used to calculate the parent's body mass index (BMI). Height, weight, age, and sex data were used to calculate the children's BMI percentile [104]. To increase accuracy of height reports, participants were instructed to measure height using the special tape measure and instructions that were mailed to their homes, along with a brief video posted on the Internet [105].

Food frequency questionnaires determined parents' daily servings of fruits/vegetables, milk, and sugar-sweetened beverages, and percent total calories from fat [106-111]. Physical activity levels were measured using the streamlined version of the International Physical Activity Questionnaire [112-114], which evaluated frequency of engaging in three levels of exercise (walking, moderate activity, heavy activity) during the past week. Parents also reported total daily time spent using sedentary screen-time devices (ie, watching television or DVDs, playing games on computers or smart phones) [98,115]. Pittsburgh Sleep Quality Index items evaluated usual daily sleep duration (hours/night) [116,117]. Using questionnaires analogous to those used with adults but appropriate for children, children's daily servings of fruit and vegetable juice, milk, and sugar-sweetened beverages [106-111,118], physical activity level [112], total daily screentime [98,115], and daily total hours of sleep (night and naps) were assessed [116,117].

Family/social interactions that were measured included family mealtime and physical activity behaviors as well as factors affecting these interactions (ie, parental self-efficacy and values). Items determined family meal frequency [119] and locations [120-122], family mealtime environment characteristics [98,120,123], family meal planning [124-127] and self-efficacy [125], and parent modeling of healthy eating behaviors [30,128,129]. Scales also assessed how frequently parents played actively with their children [98], frequency of parental modeling of physical activity and sedentary behavior to children

[114,120,123,128,130], and parental encouragement of children to be physically active [98,123,128,131,132].

Parental self-efficacy for promoting obesity-preventive behaviors in children [98,133,134] was assessed by having parents indicate how confident they felt in their abilities to keep children's weight healthy and engage in obesity-preventive eating, physical activity, and sleeping behaviors. Parental values associated with achieving obesity-preventive home environments and lifestyles were assessed with scales measuring healthy eating outcome expectations (belief in link between diet and health) [125,135], physical activity outcome expectations (belief in link between exercise and health) [125,135], and values placed on modeling physical activity [98,123,130-132], not modeling sedentary behavior [98], and physical activity for children [131,132].

The home physical environment characteristics that were assessed included household food, physical activity, and media environment. Household food availability was assessed with food frequency-type questionnaires that yielded weekly servings typically available per person in the household consisting of: salty, fatty snacks; sugar-sweetened beverages; fruits and vegetables; breakfast foods; and milk [106,107,109,118,136]. The HOP-Up Checklist assessed physical activity availability and accessibility inside the home, in the area immediately outside the home/yard, and in the neighborhood [97]. The household media environment was described with items assessing the number and types of media devices (including television) in the home [120,123,128], the daily amount of time children were allowed to watch television/movies and use inactive media devices (eg, computers, tables, smart phones) [98], and total time each day that the television was on even if no one was watching [98,123].

Data Management

At the outset of the project and continuously throughout the project, the project team established and refined data management procedures. These procedures included data file naming, processing, and storage conventions. Standard operating procedures were drafted and training modules were created. All staff involved in data collection and management were required to demonstrate competency in implementing the procedures before and during data collection or management activities. Supervisors regularly reviewed data collection and management procedures to ensure that they were followed with fidelity.

The data generated in this RCT project are primarily quantitative data gathered through surveys administered online. To ensure generated data are reliable, valid, and usable, the team strictly adhered to best practices for instrument development, online data collection, and psychometric analyses. Data generated via online survey software were downloaded in spreadsheet format at least twice weekly. Data were checked regularly to ensure accuracy of data capture. A comprehensive data dictionary that includes original items, answer choices, scoring/coding of answers, scoring of scales, and examples was created to ensure that all project data are accurately and readily usable.

To ensure the long-term preservation of the data generated in this study, during the execution of the project the research team store data files on password-protected university servers that are backed up daily. For added redundancy, all project data are shared periodically (at least twice weekly during active data collection periods) by key project staff on password-protected computers.

Data Analyses

For all outcome measures, paired *t*-tests will be used to compare within-group differences over time, and analyses of covariance (controlling for baseline scores) will be used to determine differences in midpoint, post, follow-up, and long-term follow-up of online survey scores between control and experimental groups. Hierarchical linear modeling will be used to analyze data longitudinally and compare the slope of independent variables as they change over time, as well as mean response. An overall multiple regression model will be developed to examine the difference between baseline and subsequent administration of the measures. Data for study completers and noncompleters will be examined as well, to determine how participants differ.

Results

Enrollment for this study was completed in August 2017 and statistical data analyses are underway as of March 2017.

Discussion

The HomeStyles project was designed to help families with young children shape home environments and lifestyles to promote optimal child growth and development, and prevent childhood obesity using quick, easy, low-cost strategies that can become part of their everyday lives. Using electronic technology to deliver HomeStyles materials enables parents to access materials at times and locations most convenient to them. HomeStyles was based on current obesity prevention guidelines, a multifactorial (diet, physical activity, sleep) approach, participatory planning and implementation strategies, and conveyed clear, actionable messages delivered using motivational interviewing principles [50,51,64,65]. These approaches help to ensure that HomeStyles is responsive to the wants and needs of parents with preschoolers. These considerations also increase the potential of HomeStyles' messages resonating with (and being acted on) by the target audience, thereby contributing to the long-term goal of improving health and preventing childhood obesity.

Extensive attention was devoted to overcoming challenges noted in previous studies. For example, parental reports of children's heights and weights tend to be inaccurate [137-141]. Thus, to improve parent accuracy, HomeStyles researchers developed and validated a height measurement kit [105]. This kit included a special tape measure that labeled each quarter-inch increment, a plumb line made of a metal washer and mason's line, and instructions (written and video) explaining how to hang the tape measure straight on a wall to accurately measure children. Additionally, the researchers verified that home bathroom scales provide sufficiently accurate and consistent weights for public health results [142].

All too often, the materials developed for interventions contain excellent content but poor design. Consumers have come to expect materials equivalent in quality to professional magazines and websites. The HomeStyles project avoided the *homemade* look by including a professional graphic artist who had extensive experience with both the target audience and subject matter, and was fully embedded in this project from conceptualization to execution. The resulting materials have a unified look and feel and were branded with the HomeStyles logo to promote *brand awareness*. A professional copyeditor ensured that all materials were grammatically correct and uniformly formatted.

Another challenge in the development of materials is offering them in more than one language. All HomeStyles materials were developed and fully tested in audiences whose primary language was either English or Spanish. Spanish translation is especially complicated because it is spoken in many countries, each of which has some unique phrasing and terms for common words (eg, the terms snack, lunch, and straws) that may be not be understandable in all countries. Further complicating this issue is the use of English words along with Spanish among immigrants to the United States. To address this translation challenge, HomeStyles engaged professional translators who were familiar with the subject matter and who used *in-culture* translations (ie, translations using terms and phrasing common to the vast majority of Spanish speakers). Another challenge of the Spanish translation in this project was to capture the warm, inviting, guilt-free, personalized tone that was used in the English materials. To achieve the desired tone, the professional translators were included in the development of project materials from the outset of the project, before even one word was written. In addition, many of our project staff were bilingual with varied nativity, including Chile, Bolivia, Mexico, and Puerto Rico.

Journal articles reporting nutrition RCT outcomes frequently indicate that the intervention was based on a particular behavior change theory [143,144]. However, there is rarely any indication of which constructs from the theory were used, or documentation as to where or how the theory was employed. To overcome this challenge and advance the field, the use of Social Cognitive Theory constructs and motivational interviewing strategies in the HomeStyles guides are the first (to our knowledge) to be clearly annotated. These annotations are described in detail elsewhere [43].

Recruiting study participants is a significant obstacle faced by researchers. Compounding this issue is, “a clear knowledge gap with regard to effective strategies aimed at those recruiting to trials” [145]. The HomeStyles study aimed to overcome recruitment obstacles in a variety of ways. For instance, the project used an attention control group that provided these participants a plausible, useful, bona fide treatment. An added benefit of this design is that it minimizes threats to internal validity [146-148]. The project also used intensive and varied recruitment strategies. Additionally, the project offered participants tangible incentives in the form of enhancements and stipends, as well as intangible incentives that parents indicated were important to them (eg, providing intervention materials that would help them build happier, closer bonds with their children). These incentives were used to help reduce participant attrition, which is another critical obstacle to the successful completion of intervention studies.

Effective childhood obesity prevention programs are desperately needed to reverse the obesity epidemic. To our knowledge, HomeStyles is among the first large-scale, rigorously controlled studies to test the effectiveness of a multifactorial childhood obesity prevention program that aims to help parents shape their home environments and lifestyle practices using quick, easy, low- or no-cost strategies. The thoughtfully developed, evidence-based, behaviorally focused, theory-driven content of the intervention materials is expected to enable and motivate parents to promote optimal home environments, lifestyle practices, child growth, health, and body weights.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

HomeStyles study measures.

[PDF File (Adobe PDF File), 51KB - resprot_v6i4e73_app1.pdf]

Multimedia Appendix 2

Peer review report for funded behavioral intervention study.

[PDF File (Adobe PDF File), 22KB - resprot_v6i4e73_app2.pdf]

Multimedia Appendix 3

CONSORT checklist.

[PDF File (Adobe PDF File), 567KB - resprot_v6i4e73_app3.pdf]

References

1. Crockett S, Sims L. Environmental influences in children's eating. J Nutr Educ 1995;27:235-249.
2. Patrick H, Nicklas TA. A review of family and social determinants of children's eating patterns and diet quality. J Am Coll Nutr 2005 Apr;24(2):83-92. [Medline: 15798074]
3. Shepherd J, Harden A, Rees R, Brunton G, Garcia J, Oliver S, et al. Young people and healthy eating: a systematic review of research on barriers and facilitators. Health Educ Res 2006 Apr;21(2):239-257. [doi: 10.1093/her/cyh060] [Medline: 16251223]
4. Story M, Neumark-Sztainer D, French S. Individual and environmental influences on adolescent eating behaviors. J Am Diet Assoc 2002 Mar;102(3 Suppl):S40-S51. [Medline: 11902388]
5. Kelder S, Hoelscher D, Perry C. How individuals, environments, and health behavior interact; Social Cognitive Theory. In: Glanz K, Rimer B, Viswanath K, editors. Health Behavior and Health Education: Theory, Research, and Practice. 4th Edition. San Francisco: Jossey-Bass; 2015.
6. Fulkerson JA, Neumark-Sztainer D, Story M, Gurvich O, Kubik MY, Garwick A, et al. The Healthy Home Offerings via the Mealtime Environment (HOME) Plus study: design and methods. Contemp Clin Trials 2014 May;38(1):59-68 [FREE Full text] [doi: 10.1016/j.cct.2014.01.006] [Medline: 24480729]
7. Fulkerson JA, Friend S, Flattum C, Horning M, Draxten M, Neumark-Sztainer D, et al. Promoting healthful family meals to prevent obesity: HOME Plus, a randomized controlled trial. Int J Behav Nutr Phys Act 2015 Dec 15;12:154 [FREE Full text] [doi: 10.1186/s12966-015-0320-3] [Medline: 26667110]
8. Evans AE, Dave J, Tanner A, Duhe S, Condrasky M, Wilson D, et al. Changing the home nutrition environment: effects of a nutrition and media literacy pilot intervention. Fam Community Health 2006;29(1):43-54. [Medline: 16340677]
9. Byrd-Bredbenner C, Maurer Abbot J. Improving the nutritional quality of the home food environment using self-directed home kitchen makeovers. Forum for Family and Consumer Issues 2009;14(1).
10. Maurer Abbot J, Byrd-Bredbenner C. Development of a self-directed home kitchen makeover for mothers of young children. Forum for Family and Consumer Issues 2009;14.
11. Van Horn L, Obarzanek E, Friedman LA, Gernhofer N, Barton B. Children's adaptations to a fat-reduced diet: the Dietary Intervention Study in Children (DISC). Pediatrics 2005 Jun;115(6):1723-1733. [doi: 10.1542/peds.2004-2392] [Medline: 15930237]
12. Lindström J, Ilanne-Parikka P, Peltonen M, Aunola S, Eriksson JG, Hemiö K, Finnish Diabetes Prevention Study Group. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. Lancet 2006 Nov 11;368(9548):1673-1679. [doi: 10.1016/S0140-6736(06)69701-8] [Medline: 17098085]
13. Ritchie LD, Welk G, Styne D, Gerstein DE, Crawford PB. Family environment and pediatric overweight: what is a parent to do? J Am Diet Assoc 2005 May;105(5 Suppl 1):S70-S79. [doi: 10.1016/j.jada.2005.02.017] [Medline: 15867900]
14. Rodearmel SJ, Wyatt HR, Barry MJ, Dong F, Pan D, Israel RG, et al. A family-based approach to preventing excessive weight gain. Obesity (Silver Spring) 2006 Aug;14(8):1392-1401 [FREE Full text] [doi: 10.1038/oby.2006.158] [Medline: 16988082]
15. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health 2008;29:253-272. [doi: 10.1146/annurev.publhealth.29.020907.090926] [Medline: 18031223]
16. Twisk JW, Kemper HC, van Mechelen W. Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. Med Sci Sports Exerc 2000 Aug;32(8):1455-1461. [Medline: 10949012]
17. Twisk JW, Kemper HC, van Mechelen W, Post GB. Tracking of risk factors for coronary heart disease over a 14-year period: a comparison between lifestyle and biologic risk factors with data from the Amsterdam Growth and Health Study. Am J Epidemiol 1997 May 15;145(10):888-898. [Medline: 9149660]
18. Kelder SH, Perry CL, Klepp KI, Lytle LL. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. Am J Public Health 1994 Jul;84(7):1121-1126. [Medline: 8017536]
19. Brustad RJ. Attraction to physical activity in urban schoolchildren: parental socialization and gender influences. Res Q Exerc Sport 1996 Sep;67(3):316-323. [doi: 10.1080/02701367.1996.10607959] [Medline: 8888420]
20. Demsey J, Kimiecik J, Horn T. Parental influence on children's moderate to vigorous physical activity participation: an expectancy-value approach. Pediatr Exerc 1993;5:151-167.
21. Lau RR, Quadrel MJ, Hartman KA. Development and change of young adults' preventive health beliefs and behavior: influence from parents and peers. J Health Soc Behav 1990 Sep;31(3):240-259. [Medline: 2133479]
22. Nicklas TA, Hayes D, American Dietetic Association. Position of the American Dietetic Association: nutrition guidance for healthy children ages 2 to 11 years. J Am Diet Assoc 2008 Jun;108(6):1038-44, 1046. [Medline: 18564454]
23. Patterson TL, Sallis JF, Nader PR, Kaplan RM, Rupp JW, Atkins CJ, et al. Familial similarities of changes in cognitive, behavioral, and physiological variables in a cardiovascular health promotion program. J Pediatr Psychol 1989 Jun;14(2):277-292. [Medline: 2754577]

24. Institute of Medicine, Committee on Progress in Preventing Childhood Obesity. Progress in preventing childhood obesity: how do we measure up?. Washington, DC: National Academy Press; 2007.
25. Golan M, Crow S. Parents are key players in the prevention and treatment of weight-related problems. Nutr Rev 2004 Jan;62(1):39-50. [Medline: 14995056]
26. Fisher J, Mitchell D, Smiciklas-Wright H, Birch L. Maternal milk consumption predicts the tradeoff between milk and soft drinks in young girls' diets. J Nutr 2001 Feb;131(2):246-250 [FREE Full text] [Medline: 11160541]
27. Fisher JO, Mitchell DC, Smiciklas-Wright H, Birch LL. Parental influences on young girls' fruit and vegetable, micronutrient, and fat intakes. J Am Diet Assoc 2002 Jan;102(1):58-64 [FREE Full text] [Medline: 11794503]
28. Fisher JO, Birch LL. Restricting access to foods and children's eating. Appetite 1999 Jun;32(3):405-419. [doi: 10.1006/appe.1999.0231] [Medline: 10336797]
29. Gibson EL, Wardle J, Watts CJ. Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. Appetite 1998 Oct;31(2):205-228. [doi: 10.1006/appe.1998.0180] [Medline: 9792733]
30. Wardle J, Sanderson S, Guthrie CA, Rapoport L, Plomin R. Parental feeding style and the inter-generational transmission of obesity risk. Obes Res 2002 Jun;10(6):453-462 [FREE Full text] [doi: 10.1038/oby.2002.63] [Medline: 12055321]
31. Byrd-Bredbenner C, Abbot JM. Differences in food supplies of U.S. households with and without overweight individuals. Appetite 2009 Apr;52(2):479-484. [doi: 10.1016/j.appet.2008.12.011] [Medline: 19152822]
32. Harper L, Sanders K. The effect of adults' eating on young children's acceptance of unfamiliar foods. J Exp Child Psychol 1975;20:206-214.
33. Fulkerson JA, Neumark-Sztainer D, Story M. Adolescent and parent views of family meals. J Am Diet Assoc 2006 Apr;106(4):526-532. [doi: 10.1016/j.jada.2006.01.006] [Medline: 16567147]
34. Rolland-Cachera MF, Deheeger M, Guilloud-Bataille M, Avons P, Patois E, Sempé M. Tracking the development of adiposity from one month of age to adulthood. Ann Hum Biol 1987;14(3):219-229. [Medline: 3662424]
35. Swinburn B, Egger G. The runaway weight gain train: too many accelerators, not enough brakes. BMJ 2004 Sep 25;329(7468):736-739 [FREE Full text] [doi: 10.1136/bmj.329.7468.736] [Medline: 15388619]
36. Krahnstoever DK, Francis LA, Birch LL. Reexamining obesigenic families: parents' obesity-related behaviors predict girls' change in BMI. Obes Res 2005 Nov;13(11):1980-1990 [FREE Full text] [doi: 10.1038/oby.2005.243] [Medline: 16339130]
37. Anderson SE, Whitaker RC. Household routines and obesity in US preschool-aged children. Pediatrics 2010 Mar;125(3):420-428. [doi: 10.1542/peds.2009-0417] [Medline: 20142280]
38. American Dietetic Association (ADA). Position of the American Dietetic Association: individual-, family-, school-, and community-based interventions for pediatric overweight. J Am Diet Assoc 2006 Jun;106(6):925-945. [Medline: 16812927]
39. Flynn MA, McNeil DA, Maloff B, Mutasingwa D, Wu M, Ford C, et al. Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with 'best practice' recommendations. Obes Rev 2006 Feb;7 Suppl 1:7-66. [doi: 10.1111/j.1467-789X.2006.00242.x] [Medline: 16371076]
40. Serdula MK, Khan LK, Dietz WH. Weight loss counseling revisited. JAMA 2003 Apr 09;289(14):1747-1750. [doi: 10.1001/jama.289.14.1747] [Medline: 12684339]
41. Lang A, Froelicher ES. Management of overweight and obesity in adults: behavioral intervention for long-term weight loss and maintenance. Eur J Cardiovasc Nurs 2006 Jun;5(2):102-114. [doi: 10.1016/j.ejcnurse.2005.11.002] [Medline: 16406709]
42. File T, Ryan C. Computer and Internet use in the United States, 2013: American Community Survey Reports. Washington DC: U.S. Department of Commerce, Economic and Statistics Administration; 2014. URL: https://www.census.gov/history/pdf/2013computeruse.pdf [accessed 2017-04-19] [WebCite Cache ID 6pqo4NKSl]
43. Martin-Biggers J, Spaccarotella K, Delaney C, Koenings M, Alleman G, Hongu N, et al. Development of the intervention materials for the HomeStyles obesity prevention program for parents of preschoolers. Nutrients 2015 Aug 10;7(8):6628-6669 [FREE Full text] [doi: 10.3390/nu7085301] [Medline: 26266419]
44. Martin-Biggers J, Beluska K, Quick V, Tursi M, Byrd-Bredbenner C. Cover lines using positive, urgent, unique language entice moms to read health communications. J Health Commun 2015;20(7):766-772. [doi: 10.1080/10810730.2015.1018581] [Medline: 25928099]
45. Maher EJ, Li G, Carter L, Johnson DB. Preschool child care participation and obesity at the start of kindergarten. Pediatrics 2008 Aug;122(2):322-330. [doi: 10.1542/peds.2007-2233] [Medline: 18676550]
46. Pate RR, Pfeiffer KA, Trost SG, Ziegler P, Dowda M. Physical activity among children attending preschools. Pediatrics 2004 Nov;114(5):1258-1263. [doi: 10.1542/peds.2003-1088-L] [Medline: 15520105]
47. Freedman MR, Alvarez KP. Early childhood feeding: assessing knowledge, attitude, and practices of multi-ethnic child-care providers. J Am Diet Assoc 2010 Mar;110(3):447-451. [doi: 10.1016/j.jada.2009.11.018] [Medline: 20184996]
48. Nicklas TA, Baranowski T, Baranowski JC, Cullen K, Rittenberry L, Olvera N. Family and child-care provider influences on preschool children's fruit, juice, and vegetable consumption. Nutr Rev 2001 Jul;59(7):224-235. [Medline: 11475448]
49. Lumeng JC, Gannon K, Appugliese D, Cabral HJ, Zuckerman B. Preschool child care and risk of overweight in 6- to 12-year-old children. Int J Obes (Lond) 2005 Jan;29(1):60-66. [doi: 10.1038/sj.ijo.0802848] [Medline: 15534612]
50. Miller W, Rollnick S. Motivational interviewing: preparing people to change, 3rd edition. New York: Guilford Press; 2013.
51. Rollnick S, Butler CC, Kinnersley P, Gregory J, Mash B. Motivational interviewing. BMJ 2010 Apr 27;340:c1900. [Medline: 20423957]

52. Delaney C, Barrios P, Lozada C, Soto-Balbuena K, Martin-Biggers J, Byrd-Bredbenner C. Applying common Latino magazine cover line themes to health communication. Hisp J Behav Sci 2016;38:546-558 [FREE Full text]
53. Delaney C, Martin-Biggers J, Lozada C, Povis-Alleman G, Hongu N, Byrd-Bredbenner C. Tracking change in HomeStyles: developing a goal tracker for parents of preschool-aged children. FASEB Journal 2016;30:673.
54. Delaney C, Martin-Biggers J, Povis-Alleman G, Hongu N, Byrd-Bredbenner C. Nudges: fun, motivational messages to encourage and reassure parents in the homestyles randomized controlled trial. FASEB Journal 2016;30:815.
55. Helliker K. Wall Street Journal. 2010. The power of a gentle nudge URL: https://www.wsj.com/articles/SB10001424052748704314904575250352409843386 [accessed 2017-04-19] [WebCite Cache ID 6pqonPABC]
56. King AC, Friedman R, Marcus B, Castro C, Napolitano M, Ahn D, et al. Ongoing physical activity advice by humans versus computers: the Community Health Advice by Telephone (CHAT) trial. Health Psychol 2007 Nov;26(6):718-727. [doi: 10.1037/0278-6133.26.6.718] [Medline: 18020844]
57. Bandura A. Social learning theory. Englewood Cliffs, NJ: Prentice-Hall; 1977.
58. Keller J. ARCS Model. 2016. Keller's ARCS model of motivational design URL: https://www.arcsmodel.com/ [accessed 2017-04-10] [WebCite Cache ID 6pcwtzqRx]
59. Keller J. Motivational design of instruction. In: Reigeluth C, editor. Instructional-design theories and models: an overview of their current status. Hillsdale, NJ: Lawrence Erlbaum Associates; 1983.
60. Rodriguez JC. Culturally competent dietetics: increasing awareness, improving care. J Am Diet Assoc 2010 May;110(5 Suppl):S7. [doi: 10.1016/j.jada.2010.03.035] [Medline: 20399301]
61. Speck M. Best practice in professional development for sustained educational change. ERS Spectrum 1996:33-41.
62. Knowles M, Holton E, Swanson R. The adult learner. Houston: Gulf Publishing; 1998.
63. Brookfield S. Understanding and facilitating adult learning. San Francisco: Jossey Bass; 1986.
64. Spahn JM, Reeves RS, Keim KS, Laquatra I, Kellogg M, Jortberg B, et al. State of the evidence regarding behavior change theories and strategies in nutrition counseling to facilitate health and food behavior change. J Am Diet Assoc 2010 Jun;110(6):879-891. [doi: 10.1016/j.jada.2010.03.021] [Medline: 20497777]
65. Rollnick S, Miller W, Butler C. Motivational interviewing in health care: helping patients change behavior. NY: Guilford Press; 2008.
66. 2015 Dietary Guidelines Advisory Committee. Scientific Report of the 2015 Dietary Guidelines Advisory Committee. Washington, DC: United States Department of Agriculture, United States Department of Health and Human Services; 2015. URL: https://health.gov/dietaryguidelines/2015-scientific-report/pdfs/scientific-report-of-the-2015-dietary-guidelines-advisory-committee.pdf [accessed 2017-04-19] [WebCite Cache ID 6pqqmuIWp]
67. White House Task Force on Childhood Obesity. Solving the problem of childhood obesity within a generation. Washington, DC; 2010. URL: https://letsmove.obamawhitehouse.archives.gov/sites/letsmove.gov/files/TaskForce_on_Childhood_Obesity_May2010_FullReport.pdf [accessed 2017-04-10] [WebCite Cache ID 6pcxFS23R]
68. United States Department of HealthHuman Services. Healthy People 2020: the road ahead. 2017. URL: http://www.healthypeople.gov/hp2020/ [accessed 2017-04-10] [WebCite Cache ID 6pcxHYaDM]
69. Khan LK, Sobush K, Keener D, Goodman K, Lowry A, Kakietek J, Centers for Disease Control and Prevention. Recommended community strategies and measurements to prevent obesity in the United States. MMWR Recomm Rep 2009 Jul 24;58(RR-7):1-26 [FREE Full text] [Medline: 19629029]
70. Golem DL, Martin-Biggers JT, Koenings MM, Davis KF, Byrd-Bredbenner C. An integrative review of sleep for nutrition professionals. Adv Nutr 2014 Nov;5(6):742-759 [FREE Full text] [doi: 10.3945/an.114.006809] [Medline: 25398735]
71. Martin-Biggers J, Spaccarotella K, Berhaupt-Glickstein A, Hongu N, Worobey J, Byrd-Bredbenner C. Come and get it! A discussion of family mealtime literature and factors affecting obesity risk. Adv Nutr 2014 May;5(3):235-247 [FREE Full text] [doi: 10.3945/an.113.005116] [Medline: 24829470]
72. Corda K, Quick V, Schefske S, DeCandia J, Byrd-Bredbenner C. Toward a polytheoretical framework for health behavior. Am J Health Studies 2010;25:211-230.
73. Faith MS, Van HL, Appel LJ, Burke LE, Carson JA, Franch HA, American Heart Association Nutrition and Obesity Committees of the Council on Nutrition, Physical Activity and Metabolism, Council on Clinical Cardiology, Council on Cardiovascular Disease in the Young, Council on Cardiovascular Nursing, Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease. Evaluating parents and adult caregivers as "agents of change" for treating obese children: evidence for parent behavior change strategies and research gaps: a scientific statement from the American Heart Association. Circulation 2012 Mar 6;125(9):1186-1207 [FREE Full text] [doi: 10.1161/CIR.0b013e31824607ee] [Medline: 22271754]
74. Martin-Biggers J, Spaccarotella K, Hongu N, Alleman G, Worobey J, Byrd-Bredbenner C. Translating it into real life: a qualitative study of the cognitions, barriers and supports for key obesogenic behaviors of parents of preschoolers. BMC Public Health 2015 Feb 26;15:189 [FREE Full text] [doi: 10.1186/s12889-015-1554-3] [Medline: 25886030]
75. Webber KH, Tate DF, Quintiliani LM. Motivational interviewing in internet groups: a pilot study for weight loss. J Am Diet Assoc 2008 Jun;108(6):1029-1032. [doi: 10.1016/j.jada.2008.03.005] [Medline: 18502239]

76. Beal CC, Stuifbergen A, Volker D, Becker H. Women's experiences as members of attention control and experimental intervention groups in a randomized controlled trial. Can J Nurs Res 2009 Dec;41(4):16-31. [Medline: 20191711]
77. Street LL, Luoma JB. Control groups in psychosocial intervention research: ethical and methodological issues. Ethics Behav 2002;12(1):1-30. [doi: 10.1207/S15327019EB1201_1] [Medline: 12171079]
78. United States Department of Agriculture, National Institute of Food and Agriculture, United States Department of Housing and Urban Development. Help yourself to a healthy home. Washington, DC: U.S. Government; 2012. URL: https://portal.hud.gov/hudportal/documents/huddoc?id=DOC_11880.pdf [accessed 2017-04-19] [WebCite Cache ID 6pqs82yNL]
79. Food and Drug Administration. Informacion sobre alimentos, termometros para refrigadores. Washington DC: U.S. Government; 2011. URL: https://www.fda.gov/Food/ResourcesForYou/Consumers/ucm254176.htm [accessed 2017-04-10] [WebCite Cache ID 6pcxfHnfj]
80. Food and Drug Administration. Food facts, safe food handling. Washington, DC: U.S. Government; 2011. URL: https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets [accessed 2017-04-10] [WebCite Cache ID 6pcxkWscN]
81. Food and Drug Administration. Food facts, refrigerator thermometers. Washington, DC: U.S. Government; 2011. URL: https://www.fda.gov/Food/ResourcesForYou/Consumers/ucm253954.htm [accessed 2017-04-10] [WebCite Cache ID 6pcxnvf5r]
82. Food and Drug Administration. Safe food handling, what you need to know. Washington, DC: U.S. Government; 2011. URL: https://www.fda.gov/Food/ResourcesForYou/Consumers/ucm255180.htm [accessed 2017-04-10] [WebCite Cache ID 6pcxqzxqD]
83. Food and Drug Administration. Informacion sobre alimentos, manipulacion seguar del los alimentos, lo que usted debe saber. Washington, DC: U.S. Government; 2011. URL: https://www.fda.gov/food/resourcesforyou/consumers/ucm261926.htm [accessed 2017-04-10] [WebCite Cache ID 6pcxu0fyx]
84. Food and Drug Administration. 4 basic steps to food safety at home. Washington, DC: U.S. Government; 2012. URL: https://www.fda.gov/downloads/ForConsumers/ByAudience/ForWomen/FreePublications/UCM309539.pdf [accessed 2017-04-10] [WebCite Cache ID 6pcxwaZ40]
85. Food and Drug Administration. Cuatro pasos basicos para asegurar lo inocuidad de los aliments en el hogar. Washington, DC: U.S. Government; 2012. URL: https://www.fda.gov/downloads/ForConsumers/ByAudience/ForWomen/FreePublications/UCM309551.pdf [accessed 2017-04-10] [WebCite Cache ID 6pcxzFCp7]
86. Hopewell S, Clarke M, Moher D, Wager E, Middleton P, Altman DG, et al. CONSORT for reporting randomized controlled trials in journal and conference abstracts: explanation and elaboration. PLoS Med 2008 Jan 22;5(1):e20 [FREE Full text] [doi: 10.1371/journal.pmed.0050020] [Medline: 18215107]
87. Martin-Biggers J, Cheng C, Spaccarotella K, Byrd-Bredbenner C. Recent Advances in Obesity in Children. Berlin: Avid Science Publications; 2016. The physical activity environment in homes and neighborhoods URL: http://www.avidscience.com/wp-content/uploads/2016/05/OIC-15-04_May-06-2016.pdf [accessed 2017-04-19] [WebCite Cache ID 6pqsgzOdD]
88. Martin-Biggers J, Worobey J, Byrd-Bredbenner C. Recent Advances in Obesity in Children. Berlin: Avid Science Publications; 2016. Interpersonal characteristics in the home environment associated with childhood obesity URL: http://www.avidscience.com/wp-content/uploads/2016/05/OIC-15-03_May-06-2016.pdf [accessed 2017-04-19] [WebCite Cache ID 6pqt5AxjK]
89. Byrd-Bredbenner C, Maurer AJ. Food choice influencers of mothers of young children: implications for nutrition educators. Top Clin Nutr 2008;25:198-215.
90. Widaman K, Little T, Preacher K, Sawalan G. On creating and using short forms of scales in secondary research. In: Trzesniewski K, Donnellan M, Lucas R, editors. Secondary data analysis: an introduction for psychologists. Washington, DC: American Psychological Association; 2011.
91. Redding C, Maddock J, Rossi J. The sequential approach to measurement of health behavior constructs: issues in selecting and developing measures. Californian J Health Prom 2006;4(1):83-101 [FREE Full text]
92. Linn R, Gronlund N. Measuring and assessment in teaching, 8th edition. Englewood Cliffs, NJ: Prentice-Hall; 2000.
93. Haynes S, Richard D, Kubany E. Content validity in psychological assessment: a functional approach to concepts and methods. Psychol Assess 1995;7(3):238-247.
94. Byrd-Bredbenner C, Wheatley V, Schaffner D, Bruhn C, Blalock L, Maurer J. Development of food safety psychosocial questionnaires for young adults. J Food Sci Educ 2007;6:30-37.
95. Jabine T, Straf M, Tanur J, Tourangeau R. Cognitive aspects of survey methodology: building a bridge between disciplines. Washington, DC: National Academy Press; 1984.
96. Carbone ET, Campbell MK, Honess-Morreale L. Use of cognitive interview techniques in the development of nutrition surveys and interactive nutrition messages for low-income populations. J Am Diet Assoc 2002 May;102(5):690-696. [Medline: 12008995]
97. Cheng C, Martin-Biggers J, Quick V, Spaccarotella K, Byrd-Bredbenner C. Validity and reliability of HOP-Up: a questionnaire to evaluate physical activity environments in homes with preschool-aged children. Int J Behav Nutr Phys Act 2016 Aug 18;13:91 [FREE Full text] [doi: 10.1186/s12966-016-0417-3] [Medline: 27538484]

98. Martin-Biggers J. Home environment characteristics associated with obesity risk in preschool-aged children and their mothers. New Brunswick, NJ: Rutgers, The State University of New Jersey; 2016. URL: https://rucore.libraries.rutgers.edu/rutgers-lib/51369/ [accessed 2017-04-19] [WebCite Cache ID 6pquFBPEV]
99. Centers for Disease Control and Prevention. HRQOL concepts. 2017. Why is quality of life important? URL: https://www.cdc.gov/hrqol/concept.htm [accessed 2017-04-10] [WebCite Cache ID 6pcySLwoN]
100. Centers for Disease Control and Prevention. CDC HRQOL-14 Healthy Days Measure. 2017. URL: https://www.cdc.gov/hrqol/concept.htm [accessed 2017-04-10] [WebCite Cache ID 6pcyZxBD4]
101. Hager ER, Quigg AM, Black MM, Coleman SM, Heeren T, Rose-Jacobs R, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. Pediatrics 2010 Jul;126(1):e26-e32. [doi: 10.1542/peds.2009-3146] [Medline: 20595453]
102. Hartley JE, Levin K, Currie C. A new version of the HBSC Family Affluence Scale - FAS III: Scottish qualitative findings from the international FAS Development Study. Child Indic Res 2016;9:233-245 [FREE Full text] [doi: 10.1007/s12187-015-9325-3] [Medline: 26925177]
103. Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. Soc Sci Med 2008 Mar;66(6):1429-1436. [doi: 10.1016/j.socscimed.2007.11.024] [Medline: 18179852]
104. Centers for Disease Control and Prevention. CDC Growth Charts: United States. 2016. URL: https://www.cdc.gov/nchs/nhanes.htm [accessed 2017-04-10] [WebCite Cache ID 6pcydTbZ7]
105. Yorkin M, Spaccarotella K, Martin-Biggers J, Lozada C, Hongu N, Quick V, et al. A tool to improve parental measurements of preschool child height. Adv Public Health 2015;2015:2015 [FREE Full text]
106. Nelson MC, Lytle LA. Development and evaluation of a brief screener to estimate fast-food and beverage consumption among adolescents. J Am Diet Assoc 2009 Apr;109(4):730-734 [FREE Full text] [doi: 10.1016/j.jada.2008.12.027] [Medline: 19328271]
107. West DS, Bursac Z, Quimby D, Prewitt TE, Spatz T, Nash C, et al. Self-reported sugar-sweetened beverage intake among college students. Obesity (Silver Spring) 2006 Oct;14(10):1825-1831 [FREE Full text] [doi: 10.1038/oby.2006.210] [Medline: 17062813]
108. Wakimoto P, Block G, Mandel S, Medina N. Development and reliability of brief dietary assessment tools for Hispanics. Prev Chronic Dis 2006 Jul;3(3):A95 [FREE Full text] [Medline: 16776896]
109. Block G, Gillespie C, Rosenbaum EH, Jenson C. A rapid food screener to assess fat and fruit and vegetable intake. Am J Prev Med 2000 May;18(4):284-288. [Medline: 10788730]
110. Block G, Hartman AM, Naughton D. A reduced dietary questionnaire: development and validation. Epidemiology 1990 Jan;1(1):58-64. [Medline: 2081241]
111. Block G, Thompson FE, Hartman AM, Larkin FA, Guire KE. Comparison of two dietary questionnaires validated against multiple dietary records collected during a 1-year period. J Am Diet Assoc 1992 Jun;92(6):686-693. [Medline: 1607564]
112. Quick V, Byrd-Bredbenner C, Shoff S, White A, Lohse B, Horacek T, et al. A streamlined, enhanced self-report physical activity measure for young adults. Int J Health Promot Educ 2016;54(5):245-254.
113. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act 2011;8:115 [FREE Full text] [doi: 10.1186/1479-5868-8-115] [Medline: 22018588]
114. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003 Aug;35(8):1381-1395. [doi: 10.1249/01.MSS.0000078924.61453.FB] [Medline: 12900694]
115. Owen N, Sugiyama T, Eakin EE, Gardiner PA, Tremblay MS, Sallis JF. Adults' sedentary behavior determinants and interventions. Am J Prev Med 2011 Aug;41(2):189-196. [doi: 10.1016/j.amepre.2011.05.013] [Medline: 21767727]
116. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989 May;28(2):193-213. [Medline: 2748771]
117. Carpenter JS, Andrykowski MA. Psychometric evaluation of the Pittsburgh Sleep Quality Index. J Psychosom Res 1998 Jul;45(1):5-13. [Medline: 9720850]
118. Hunsberger M, O'Malley J, Block T, Norris JC. Relative validation of Block Kids Food Screener for dietary assessment in children and adolescents. Matern Child Nutr 2015 Apr;11(2):260-270. [doi: 10.1111/j.1740-8709.2012.00446.x] [Medline: 23006452]
119. Koszewski W, Behrends D, Nichols M, Sehi N, Jones G. Patterns of family meals and food and nutrition intake in limited resource families. Fam Consum Sci Res J 2011;39:431-441.
120. Bryant MJ, Ward DS, Hales D, Vaughn A, Tabak RG, Stevens J. Reliability and validity of the Healthy Home Survey: a tool to measure factors within homes hypothesized to relate to overweight in children. Int J Behav Nutr Phys Act 2008 Apr 28;5:23 [FREE Full text] [doi: 10.1186/1479-5868-5-23] [Medline: 18442392]
121. Neumark-Sztainer D, Story M, Hannan PJ, Croll J. Overweight status and eating patterns among adolescents: where do youths stand in comparison with the healthy people 2010 objectives? Am J Public Health 2002 May;92(5):844-851. [Medline: 11988458]

122. Neumark-Sztainer D, Wall MM, Story M, Perry CL. Correlates of unhealthy weight-control behaviors among adolescents: implications for prevention programs. Health Psychol 2003 Jan;22(1):88-98. [Medline: 12558206]
123. Spurrier NJ, Magarey AA, Golley R, Curnow F, Sawyer MG. Relationships between the home environment and physical activity and dietary patterns of preschool children: a cross-sectional study. Int J Behav Nutr Phys Act 2008 May 30;5:31 [FREE Full text] [doi: 10.1186/1479-5868-5-31] [Medline: 18513416]
124. Neumark-Sztainer D, Larson NI, Fulkerson JA, Eisenberg ME, Story M. Family meals and adolescents: what have we learned from Project EAT (Eating Among Teens)? Public Health Nutr 2010 Jul;13(7):1113-1121. [doi: 10.1017/S1368980010000169] [Medline: 20144257]
125. Byrd-Bredbenner C, Abbot JM, Cussler E. Relationship of social cognitive theory concepts to mothers' dietary intake and BMI. Matern Child Nutr 2011 Jul;7(3):241-252. [doi: 10.1111/j.1740-8709.2009.00232.x] [Medline: 21689267]
126. Candel M. Consumers' convenience orientation towards meal preparation: conceptualization and measurement. Appetite 2001 Feb;36(1):15-28. [doi: 10.1006/appe.2000.0364] [Medline: 11161342]
127. Neumark-Sztainer D, Hannan PJ, Story M, Croll J, Perry C. Family meal patterns: associations with sociodemographic characteristics and improved dietary intake among adolescents. J Am Diet Assoc 2003 Mar;103(3):317-322. [doi: 10.1053/jada.2003.50048] [Medline: 12616252]
128. Gattshall ML, Shoup JA, Marshall JA, Crane LA, Estabrooks PA. Validation of a survey instrument to assess home environments for physical activity and healthy eating in overweight children. Int J Behav Nutr Phys Act 2008 Jan 11;5:3 [FREE Full text] [doi: 10.1186/1479-5868-5-3] [Medline: 18190709]
129. Ogden J, Reynolds R, Smith A. Expanding the concept of parental control: a role for overt and covert control in children's snacking behaviour? Appetite 2006 Jul;47(1):100-106. [doi: 10.1016/j.appet.2006.03.330] [Medline: 16682098]
130. Earls F, Brooks-Gunn J, Raudenbush S, Sampson R. Project on human development in Chicago neighborhoods (PHDCN). 1997. Home and life interview, wave 2 URL: http://www.icpsr.umich.edu/icpsrweb/NACJD/studies/13630 [accessed 2017-04-10] [WebCite Cache ID 6pcysgGK8]
131. Sallis JF, Prochaska JJ, Taylor WC, Hill JO, Geraci JC. Correlates of physical activity in a national sample of girls and boys in grades 4 through 12. Health Psychol 1999 Jul;18(4):410-415. [Medline: 10431943]
132. Trost SG, Sallis JF, Pate RR, Freedson PS, Taylor WC, Dowda M. Evaluating a model of parental influence on youth physical activity. Am J Prev Med 2003 Nov;25(4):277-282. [Medline: 14580627]
133. Kiernan M, Moore SD, Schoffman DE, Lee K, King AC, Taylor CB, et al. Social support for healthy behaviors: scale psychometrics and prediction of weight loss among women in a behavioral program. Obesity (Silver Spring) 2012 Apr;20(4):756-764 [FREE Full text] [doi: 10.1038/oby.2011.293] [Medline: 21996661]
134. Ball K, Crawford D. An investigation of psychological, social and environmental correlates of obesity and weight gain in young women. Int J Obes (Lond) 2006 Aug;30(8):1240-1249. [doi: 10.1038/sj.ijo.0803267] [Medline: 16491107]
135. AbuSabha R, Achterberg C. Review of self-efficacy and locus of control for nutrition- and health-related behavior. J Am Diet Assoc 1997 Oct;97(10):1122-1132. [doi: 10.1016/S0002-8223(97)00273-3] [Medline: 9336559]
136. Martin-Biggers J, Koenings M, Quick V, Abbot JM, Byrd-Bredbenner C. Appraising nutrient availability of household food supplies using Block Dietary Screeners for individuals. Eur J Clin Nutr 2015 Sep;69(9):1028-1034. [doi: 10.1038/ejcn.2015.30] [Medline: 25804271]
137. Skinner AC, Skelton JA. Prevalence and trends in obesity and severe obesity among children in the United States, 1999-2012. JAMA Pediatr 2014 Jun;168(6):561-566. [doi: 10.1001/jamapediatrics.2014.21] [Medline: 24710576]
138. Akinbami LJ, Ogden CL. Childhood overweight prevalence in the United States: the impact of parent-reported height and weight. Obesity (Silver Spring) 2009 Aug;17(8):1574-1580 [FREE Full text] [doi: 10.1038/oby.2009.1] [Medline: 19629061]
139. Dubois L, Girad M. Accuracy of maternal reports of pre-schoolers' weights and heights as estimates of BMI values. Int J Epidemiol 2007 Feb;36(1):132-138. [doi: 10.1093/ije/dyl281] [Medline: 17510077]
140. Wing R, Epstein L, Neff D. Accuracy of parents' reports of height and weight. J Behavior Assess 1980;2(2):105-110.
141. O'Connor DP, Gugenheim JJ. Comparison of measured and parents' reported height and weight in children and adolescents. Obesity (Silver Spring) 2011 May;19(5):1040-1046 [FREE Full text] [doi: 10.1038/oby.2010.278] [Medline: 21127476]
142. Yorkin M, Spaccarotella K, Martin-Biggers J, Quick V, Byrd-Bredbenner C. Accuracy and consistency of weights provided by home bathroom scales. BMC Public Health 2013 Dec 17;13:1194. [doi: 10.1186/1471-2458-13-1194] [Medline: 24341761]
143. Contento I, Randell J, Basch C. Review and analysis of evaluation measures used in nutrition education intervention research. J Nutr Educ Behav 2002;34:2-25. [Medline: 11917668]
144. Diep C, Chen T, Davies V, Baranowski J, Baranowski T. Influence of behavioral theory on fruit and vegetable intervention effectiveness among children: a meta-analysis. J Nutr Educ Behav 2014;46(6):506-546. [doi: 10.1016/j.jneb.2014.05.012] [Medline: 25457730]
145. Treweek S, Lockhart P, Pitkethly M, Cook JA, Kjeldstrøm M, Johansen M, et al. Methods to improve recruitment to randomised controlled trials: Cochrane systematic review and meta-analysis. BMJ Open 2013;3(2) [FREE Full text] [doi: 10.1136/bmjopen-2012-002360] [Medline: 23396504]
146. Fogg L, Gross D. Threats to validity in randomized clinical trials. Res Nurs Health 2000;23:79-87. [Medline: 10686575]

147. Jensen P, Weersing R, Hoagwood K, Goldman E. What is the evidence for evidence-based treatments? A hard look at our soft underbelly. Mental Health Serv Res 2005;7:53-74. [Medline: 15832693]
148. Lindquist R, Wyman J, Talley K, Findorff M, Gross C. Design of control-group conditions in clinical trials of behavioral interventions. J Nurs Scholar 2007;39:214-221. [Medline: 17760793]

Abbreviations

ARCS: Attention, Relevance, Confidence, Satisfaction
BMI: body mass index
HOP-Up: Home Opportunities for Physical activity check-Up
RCT: randomized controlled trial

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Protocol

Testing a Computerized Cognitive Training Protocol in Adults Aging With HIV-Associated Neurocognitive Disorders: Randomized Controlled Trial Rationale and Protocol

David Vance[1], MS, PhD; Pariya Fazeli[1], MS, PhD; John Shacka[2], PhD; William Nicholson[1], RN, MS; Peggy McKie[1], MPH; James Raper[3], PhD; Andres Azuero[1], PhD; Virginia Wadley[4], PhD; Karlene Ball[4], PhD

[1]School of Nursing, University of Alabama at Birmingham, Birmingham, AL, United States

[2]Department of Pharmacology & Toxicology, University of Alabama at Birmingham, Birmingham, AL, United States

[3]School of Medicine, University of Alabama at Birmingham, Birmingham, AL, United States

[4]Department of Psychology, University of Alabama at Birmingham, Birmingham, AL, United States

Corresponding Author:
David Vance, MS, PhD
School of Nursing
University of Alabama at Birmingham
1701 University Boulevard
Birmingham, AL, 35294
United States
Phone: 1 2059347589
Fax: 1 2059967183
Email: devance@uab.edu

Abstract

Background: HIV-associated neurocognitive disorders occur in nearly 50% of adults with HIV. Such disorders can interfere with everyday functioning such as driving and medication adherence. Therefore, cognitive interventions are needed to address such neurocognitive disorders as well as improve everyday functioning, especially as people age with HIV.

Objective: This article reports and discusses the overall rationale and development of speed of processing training, a computerized Internet cognitive training program, to improve this specific neurocognitive ability as well as everyday functioning and quality of life in adults aging with HIV. Although this protocol has been shown to improve speed of processing, everyday functioning, and quality of life in healthy, community-dwelling older adults in the advanced cognitive training in vital elderly (ACTIVE) study, its efficacy in adults aging with HIV has not been established. Nevertheless, such a cognitive intervention is particularly germane as 52%-59% of adults with HIV experience HIV-associated neurocognitive disorders (HAND), and both the frequency and severity of such disorders may increase with advancing age.

Methods: The description of this longitudinal randomized controlled trial covers the following: (1) rationale for speed of processing training in this clinical population, (2) overview of overall study design, (3) eligibility criteria and HAND, (4) intervention dosage, (5) assessment battery, and (6) examination of biomarkers.

Results: The project was funded in April 2016 and enrolment is on-going. The first results are expected to be submitted for publication in 2020.

Conclusions: Similar novel cognitive intervention approaches are suggested as they may be of value to those with HAND and may utilize similar features of this current randomized controlled trial (RCT) protocol to examine their therapeutic efficacy.

Trial Registration: ClinicalTrials.gov NCT02758093; https://clinicaltrials.gov/ct2/show/NCT02758093 (Archived by Webcite at http://www.webcitation.org/6p8C5fBCX)

(JMIR Res Protoc 2017;6(4):e68) doi:10.2196/resprot.6625

KEYWORDS

cognitive aging; cognitive remediation therapy; cognition therapy; HIV associated cognitive motor complex

Introduction

Combination antiretroviral therapy (cART) has resulted in improved health-related outcomes and longer life in adults with human immunodeficiency virus (HIV), with some studies estimating length of life being tantamount to those without HIV [1]. Despite such optimism, neuroinflammation, substance abuse, stress, stigma, depression and anxiety, and poorer educational quality often associated with HIV may contribute to other poorer health-related outcomes such as neurocognitive impairment, often referred to as HIV-associated neurocogntiive disorders (HAND) [2]. HAND is an objective diagnosis determined by administration of a neurocognitive assessment measuring at least seven neurocognitive domains (eg, speed of processing, verbal memory). With such an assessment, when patients score greater than 1 standard deviation below their age and education norm on 2 or more neurocognitive domains, they are considered to have HAND; this classification rubric is referred to as the Frascati criteria [3]. Using the Frascati criteria, 52% to 59% of adults with HIV experience HAND [4]. Furthermore, there are gradations of HAND of increasing severity in terms of the neurocognitive and everyday functioning impairments, with ~33% experiencing asymptomatic neurocognitive impairment, ~12% experiencing mild neurocognitive disorder, ~5% experiencing mixed neurocognitive disorder, and ~2% experiencing HIV-associated dementia [5].

With such well documented neurocognitive impairments, neurocognitive aging in this group represents a major concern since by 2020, 70% of adults with HIV in the United States will be 50 years and older [6,7]. Thus, there is a growing population that is particularly vulnerable to HAND due to the cooccurrence with aging-related neurocognitive impairments as well as age-related comorbidities that likewise compromise brain health. For example, in a study of 162 older (50+ years) and younger (<50 years) adults with and without HIV, Vance and colleagues [8] found as a group, older adults experienced more neurocognitive impairments. Such neurocognitive impairments affect driving safety, medication adherence, instrumental activities of daily living, and quality of life [9-13]. Furthermore, in the cART era, these neurocognitive impairments continue to be observed in several domains including memory, executive functioning, and 1 area of particular importance—speed of processing [14-29].

Speed of processing is the rate at which neurocognitive functions are performed [30-32]. People with HIV are vulnerable to speed of processing declines [33,34], especially as they age [30-32]. In a meta-analysis of 41 HIV neurocognitive studies from both the pre- and post-cART era [33], speed of processing was among the neurocognitive domains demonstrating the greatest decline from early to late stages of HIV for all ages. More recent studies also show that speed of processing deficits are common and persist in the post-cART era [14-29]. In fact, a 2014 study of 186 adults with HIV found that speed of processing "fully mediated the effects of age on learning, memory, and executive functioning and partially mediated the effect of major depressive disorder on learning and memory" (p. 806) [35] while other HIV studies show speed of processing deficits impair real-world functioning [13,36]. Such speed of processing declines are associated with poorer driving performance and more at-fault crashes in healthy older adults [30,37,38] as well as middle-aged (40+ years) and older adults with HIV [10,13,39,40], which is a growing public health concern [10,13,39]. In the Southern United States, specifically in the Deep South, these points are highly relevant because (1) even with speed of processing declines, adults with HIV must rely on their own driving, especially in rural areas with limited public transportation; and (2) the epicenter of HIV has emerged here in the last decade [41,42], which means many adults with lower socioeconomic status backgrounds and African Americans with HIV will also have HAND [43,44]. Few behavioral interventions have aimed to improve neurocognition in this vulnerable population [45], and pharmacological cognitive interventions produce adverse side effects in a population already experiencing multiple comorbidities [45-50].

Fortunately, some types of computerized cognitive interventions have been shown to improve neurocognition without adverse side-effects [51-53]. Despite the known efficacy of computerized cognitive training programs, only 2 such studies have examined this in adults with HIV. One study attempted to improve global neurocognition in a mixed sample of 30 adults with and 30 adults without HIV; unfortunately, only 54% (25/46) of those assigned to the active condition were able to use the system successfully and probably as a result, no therapeutic neurocognitive benefit was derived [54]. Yet, in 1 study involving adults aged 40+ years with HIV, Vance and colleagues [55] randomly assigned 22 to receive 10 hours of speed of processing training and 24 to receive a no-contact control condition. Compared with the no-contact control group, those who received the speed of processing training improved significantly on a measure of visual speed of processing called the useful field of view (UFOV) test as well as on the timed instrumental activities of daily living test, which is a laboratory measure of everyday functioning. Related to everyday functioning, a subsequent cross-sectional driving simulator study by Vance and colleagues [13] also demonstrated that in 26 adults aged 40+ years with HIV, poorer visual speed of processing was predictive of poorer driving ability (eg, average gross reaction time, divided attention reaction time). In fact, more self-reported automobile accidents in the previous 2 years were associated with slower gross reaction time and a higher number of collisions in the driving simulator. Although this was not a cognitive training study, the results suggest that improving speed of processing may likewise improve driving in aging adults with HIV.

Targeting an intervention that specifically improves speed of processing has both theoretical and neurocognitive appeal. According to the diminished speed of processing theory [32,56-59], the rate at which adults mentally process information slows with age. Speed of processing declines can occur at all stages of processing, from the speed at which information is encoded to the execution of a response [60,61]. This reduction in speed of processing places demands on other neurocognitive systems [31]. For example, Lindenberger et al [62] found that age-related decrements in memory, reasoning, and fluency were all mediated through differences in speed of processing. A

subsequent study showed that increased age affects speed of processing (effect size=−0.69) to a greater degree than memory (effect size=−0.25), or executive functioning or reasoning (effect size=−0.27), thus reinforcing the focus on speed of processing [63]. Furthermore, electrophysiological studies already indicate that adults who receive speed of processing training, compared with controls, experience increased N2pc and P3b amplitudes (electrical signals detected on the scalp), which is reflective of capacity enhancement and attentional allocation [64]. The lack of attentional and inhibition control associated with prefrontal dysregulation, especially in HIV [65,66], may be an inefficient way to process information quickly and accurately. Thus, speed of processing training may reduce dependence on frontally-oriented activity by reallocating such responses to such posterior brain regions which can improve speed of processing and in turn translate to everyday functional improvements [64,67].

Based on findings from these earlier studies, this study was proposed and funded by the National Institute of Mental Health (1R01MH106366-01A1 – "An RCT of Speed of Processing Training in Middle-Aged and Older Adults with HIV"). This randomized controlled trial (RCT) study described in this article examines a well-documented intervention in the neurocognitive and gerontological literature called speed of processing training (a cognitive remediation therapy) in the population of aging adults with HIV. Specifically, there are 3 study aims: To (1) examine whether 10 versus 20 hours of speed of processing training provides differential therapeutic responses on improving this neurocognitive ability over time; (2) examine whether 10 versus 20 hours of speed of processing training will differ in therapeutic value on improving everyday functioning (ie, IADLs, driving) over time; and (3) examine whether improvement in speed of processing and everyday functioning over time mediate improvement in quality of life indices (eg, depression, locus of control, health-related quality of life). In doing so, these 6 key areas of the study are described: (1) rationale for speed of processing training in this clinical population, (2) overview of study design, (3) eligibilty criteria and HAND, (4) intervention dosage versus control condition, (5) assessment battery, and (6) assessment of biomarkers. Finally, the complexity of this research design is examined in relation to other cognitive interventions.

Methods

Rationale of Speed of Processing Training

Several computerized cognitive training programs have been examined in the normal geriatric population; some focus on improving functioning in a particular neurocognitive domain such as executive functioning or memory, whereas others attempt to improve more global neurocognitive functioning. Albeit, given the resources of time and effort required to engage in training programs, selecting which neurocognitive domain to be "improved" must be chosen judiciously. Whereas some experts and clinicians may focus on memory training given its salience to noticeable memory complaints, others have found targeting other domains to have more long-lasting effects that likewise produce improvements in other areas in which training was not targeted.

In the advanced cognitive training in vital elderly (ACTIVE) study, researchers from 6 sites across the United States randomized normal, community-dwelling older adults (65+ years; N=2802) to 1 of the following treatment arms: (1) speed of processing training, (2) memory training, (3) reasoning training, and (4) no-contact control. After just 10 hours of training, those in the speed of processing training group experienced significant improvements in this neurocognitive ability. In fact, the National Institute on Nursing Research and the National Institute on Aging (January 14, 2014) announced that speed of processing training used in the ACTIVE study enabled "older people to maintain their cognitive abilities as they age," even 10 years after training [68]. Furthermore, in a meta-analysis of 52 computerized cognitive training studies, Lampit and colleagues [52] found that treatment effect sizes varied widely depending on what neurocognitive domain was being targeted. No significant effect sizes were observed for cognitive training that targeted executive functioning or attention, whereas statistically significant small to moderate effect sizes were observed for verbal memory (g=0.08), working memory (g=0.22), nonverbal memory (g=0.24), and visuospatial skills (g=0.30), with the most robust finding observed for speed of processing training (g=0.31). These data suggest that this particular neurocognitive domain may be more amenable than others for improvement during neurorehabilitation.

To promote successful aging and optimal functioning in the aging HIV population, speed of processing is a preferred target for this cognitive training intervention based on the following points. First, speed of processing is 1 of the most essential neurocognitive abilities that declines with aging, beginning in one's 40s [69-71]. With HIV considered as a form of accelerated aging [72,73], concerns about more profound speed of processing declines in this population increase. Second, speed of processing declines are related to poorer everyday functioning (eg, driving, performing IADLS) as well as lower quality of life (eg, health-related quality of life) [74]. Third, speed of processing training has been shown to improve this neurocognitive ability [75,76]. Fourth, this improvement in speed of processing has been shown to translate into improved driving performance, mobility, and performance on IADLs [77-83]. Fifth, in community-dwelling older adults, these neurocognitive improvements (ie, using a speed of processing measure called useful field of view) have been shown to be robust over several years; such long-term improvements may also be produced in adults with HIV. Finally, in the ACTIVE study, additional beneficial outcomes have been identified as a result of speed of processing training that include: (1) improved self-rated health [84], internal locus of control [85,86], and health-related quality of life [87-89]; and (2) protection against depression [90]. These outcomes reflect areas that must be addressed in adults with HIV who also may have reduced health-related quality of life [91-93], poor self-rated health [94], decreased locus of control [92,95-97], and depression [45,91,97,98]. These quality of life outcomes are essential areas in HIV that likewise require intervention [99]. This RCT of 264 adults with HAND extends the ability to demonstrate whether

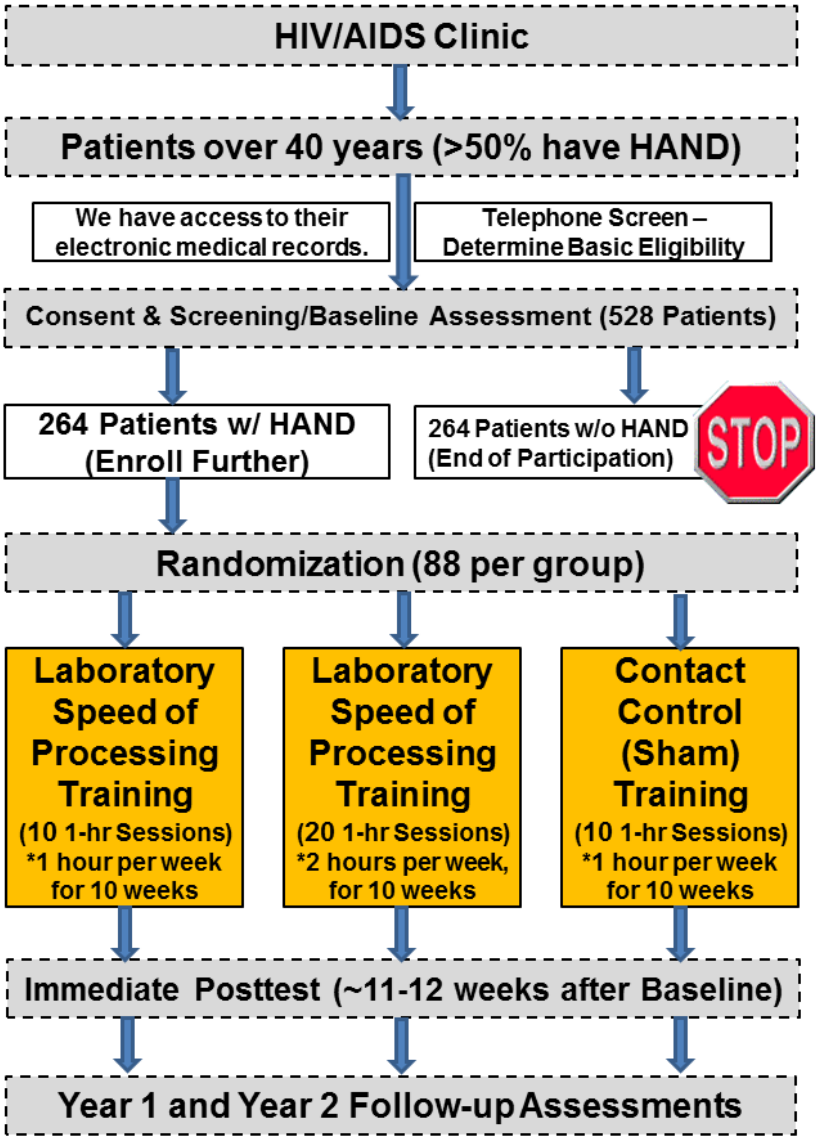
speed of processing training can improve speed of processing and everyday functioning not only in the short-term, but also during an extended 2-year period.

Overview of Overall Study Design

A pre-post 3-group experimental longitudinal design is used (Figure 1). Participants with HAND are administered a neurocognitive, functional, and quality of life assessment battery at baseline, approximately 11-12 weeks postintervention and annually for up to 2 years. This translational science study recruits adults 40+ years with HAND and assigns them to 1 of 3 groups: (1) 10 hours of speed of processing training, (2) 20 hours of speed of processing training, and (3) 10 hours of Internet navigation training (ie, a contact-control condition).

Recruitment flyers are posted at a university HIV and acquired immunodeficiency syndrome (AIDS) clinic targeting those 40+ years only. Interested potential participants call the study telephone number to be told more about the study and to determine if they meet basic eligibility requirements (eg, HIV+, 40+ years); if they do, they are scheduled for a baseline assessment appointment. During this appointment, participants are consented and administered a neurocognitive, everyday functioning, and quality of life assessment. From this assessment, a HAND diagnosis is determined. Based on prior prevalence rates, it is expected over half of the participants experience HAND; only those with HAND and thus who need such a cognitive intervention are randomly assigned to 1 of the 3 treatment arms. Block stratified random assignment will minimize the risk of imbalance among randomized groups in 2 key factors: minority status and speed of processing deficiency measured by a cut off using the useful field of view test [100]. Completion of each arm should take participants approximately 10 weeks. After training, participants are administered the same baseline assessment at posttest and then annually for 2 years. Two years of follow-up is justified because it is needed to determine the robustness of the speed of processing training over time in this clinical population as observed in the older adults in the ACTIVE study. To retain participants over a 2-year period, several strategies are employed; here are a few examples: (1) sending reminder holiday and birthday cards to participants; (2) providing little gifts to participants with the study name, phone number, and logo on them; and (3) gathering information on secondary contacts of people they know so we can track them down in case such participants move. In addition, participants are compensated for their time they spend with the study.

Figure 1. Overall study design flowchart.



Recruitment Protocol, Rationale, and Targeting HAND

Eligibility criteria specifically focus on casting a wide net to ensure that the study findings are generalizable to the larger HIV population. Albeit, given the focus on driving and neurocognition, certain inclusion, exclusion, and HAND criteria were chosen.

Inclusion Criteria

Since driving-related factors are being examined as 1 of the outcomes of the intervention, participants must be licensed drivers when entering the study. Otherwise, participants (men and women) must be 40+ years, English-speaking, and have HAND.

Exclusion Criteria

Due to this study being longitudinal, participants not living in stable housing (eg, halfway house) are excluded because of the challenge of scheduling follow-up visits. Potential participants are excluded if they indicate that they are planning to move away from the Birmingham metropolitan area within the next 2 years. Furthermore, participants with significant neuromedical comorbidities (eg, schizophrenia, epilepsy, bipolar disorder, multiple sclerosis, Alzheimer disease or related dementias, mental retardation) are excluded; such major neurological comorbidities may confound study results and interfere with the cognitive training. These comorbidities are assessed in the telephone screen and confirmed after the baseline assessment using the university HIV and AIDS Clinic electronic medical charts. Other conditions (eg, legally blind or deaf [vision

confirmed at baseline], currently undergoing radiation or chemotherapy, a history of brain trauma with a loss of consciousness greater than 30 minutes) that could impact neurocognitive functioning or testing also necessitates exclusion; again, this information is conferred in the telephone screen and again at baseline. These typical exclusion criteria are used in many HIV neurocognitive studies [12,14,101-104]; we wish to exclude those with other major neurological conditions besides HIV that affect neurocognition.

HIV-Associated Neurocognitive Disorders

This study focuses on HAND and speed of processing training. Typically, speed of processing declines emerge in one's 40s [70] and perhaps even earlier for those with HIV, which likely contributes to HAND [73]. In fact, the prevalence of HAND may be greater in middle-aged and older adults with HIV [12,18,105,106]. Primary reasons for the focus on HAND are: (1) participants have room to improve neurocognitively from speed of processing training (ie, no ceiling effects), and (2) a cognitive intervention for HAND is needed. Using a neurocognitive battery that measures performance in several neurocognitive domains, the Frascati criteria is used to determine HAND [104]. If a participant's neurocognitive scores are greater than 1 standard deviation below demographically-adjusted means in at least two neurocognitive domains (eg, memory, speed of processing), they are determined to have HAND. Further breakdown of the type of HAND diagnosis can be made based upon functional impairment too (ie, Lawton and Brody activities of daily living) to compare differences in treatment response for those with varying severity of HAND. In consensus, 2 doctorally-trained psychologists determine HAND based upon the demographically adjusted *t* scores.

Intervention Dosage Versus Control Condition

Both the speed of processing and contact-control training protocols require participants to visit the laboratory to engage in 1-hour sessions with passive supervision from a research assistant. The research assistant greets participants, helps them log onto the computer, answers questions participants may have about the training, and monitors the time participants engage in their assigned treatment arm.

In the speed of processing training protocol, participants are trained to improve the speed or accuracy in which they identify and locate visual-spatial information using 5 games or exercises from the POSIT Science, which has been used in our prior studies. The games include: (1) Sweep Seeker (fundamental speed of processing), (2) Bird Safari (visual accuracy), (3) Target Tracker (multiple object tracking), (4) Master Gardener (eye movements), and (5) Double Decision (UFOV). These games are automatically customized to the participants' individual ability. The speed, difficulty, and complexity of each game is systematically increased as participants successfully master specified performance criteria. Manipulations used to increase difficulty include decreasing the duration for which the visual stimuli are presented, adding visual or auditory distracters, increasing similarity between targets or distracters, and presenting visual targets over a broader spatial expanse, which expands one's (UFOV) and is important for driving [107]. Studies using speed of processing training often vary from 10 to 20 hours. As mentioned in the prior study in adults with HIV, 10 hours of training was sufficient to produce significant improvement in UFOV and everyday functioning in the short-term. The NIH-funded ACTIVE study (N=2802 normal older adults) also initially used 10 hours of speed of processing training, but additional "booster" training was found to improve the effect size and these improvements were robust over several years [108]. A meta-analysis [52] of cognitive training in older adults found specifically for speed of processing training, a dose of 20 hours or less produced a significantly higher effect size (0.34) compared with more than 20 hours (0.24). Given these dosage considerations, in this study 1 treatment arm receives 10 hours of training and 1 treatment arm receives 20 hours of training, whereas the control arm of the study will receive 10 hours of nontherapeutic computer contact. This approach will allow our study to determine the optimal therapeutic dosage over time. Likewise, conclusions from this meta-analysis [52] suggest that optimal effect sizes from speed of processing training for our study will be observed when training sessions are at 60 minutes and administered 1-3 times per week—dosage parameters already incorporated in this study.

In the contact-control group, participants receive 10 hours of Internet navigation training; it has been used successfully as an optimal social or computer contact-control condition for speed of processing training studies. This contact-control (sham) condition mirrors speed of processing training with the same amount of social contact with study staff and computer exposure, but does not provide any therapeutic neurocognitive benefit as we have previously observed [75,81,109]. Specifically, participants are given instructional materials and exercises on how to navigate the Internet. For more computer savvy participants, they are directed to other websites that may be of interest. These Internet activities reflect those which people do normally and do not have any observable neurocognitive therapeutic effect. This approach has been used in prior National Institute on Aging-sponsored studies [75]. This contact-control group is being used to compare with the other intervention in which only 10 hours of the speed of processing training are being provided; this will allow for a direct comparison. Meanwhile, the intervention with 20 hours of training is being included to test whether the extra dosage will be more effective versus 10 hours of speed of processing training alone.

Finally, a treatment fidelity checklist is used so staff can review with participants the amount of time that they have engaged in training. Furthermore, the POSIT Science software monitors the amount of time participants spend engaged in each exercise. As in the ACTIVE study, participants are considered to be trained when they successfully complete 80% of the training [107]. This completer-only analysis is appropriate for use when examining the actual potential of the speed of processing training. If participants do not complete training, their data can be examined using an intent-to-treat analysis.

Results

The project was funded in April 2016 and enrolment is on-going. The first results are expected to be submitted for publication in

2020. Study measures are assessed at baseline, immediate posttest following training, and at 2 annual follow-ups. These assessments are categorized by: (1) demographic, background, and covariate measures; (2) Aim 1, neurocognitive measures; (3) Aim 2, everyday functioning measures; (4) Aim 3, quality of life measures (see Table 1). Most of these measures use standardized instruments that have good to excellent psychometric properties; this is particularly relevant for the neurocognitive assessments as they are used to determine HAND [12,55,110-118].

Table 1. General domains assessed overtime.

Demographic, background, and covariate measures	Aim 1: Neurocognitive measures	Aim 2: Everyday functioning measures	Aim 3: Quality of life measures
Demographic questionnaire	Speed of processing (ie, UFOV[b]) [120]	Driving simulator [13,82,107]	Centers for epidemiological studies-Depression (CES-D) [128,129]
Wide range achivement test- 4 (Educational quality) [119]	Attention and working memory (PASAT[a]-2000) [121]	Driving habits questionnaire [124]	Internal locus of control [85]
Drug urine screen	Learning ie, Hopkins verbal learning test- Revised) [115,116,122]	Retrospective & prospective state crash records [125]	Self-rated health and health related quality of life (measured via medical outcomes study short-form (SF-36) [130]
HIV history and status	Verbal memory (ie, Hopkins verbal learning test- Revised) [115,116,122]	Timed instrumental activities of daily living [126,127]	Neurocognitive Complaints
Electronic medical records	Verbal fluency (ie, controlled oral work association test) [123]	Medication aherence	
	Executive function (ie, Wisconscin card sorting test)		
	Psychomotor (ie, grooved pegboard)		
	Reported instrumental activities of daily living (IADLs) (ie, Lawton & Brody activities of daily living questionnaire)		

[a]PASAT: Paced auditory serial attention test.

[b]UFOV: Useful field of view.

One primary and novel focal area of this study (Aim 2) is driving and driving-related outcomes. Most adults with HIV experience some degree of neurocognitive impairment, and coupled with the lack of adequate public transportation or social support, many adults must rely on their own driving and navigational skills to carry out basic IADLs such as grocery shopping and visiting their medical providers. Thus, this cognitive intervention is expected to benefit such driving outcomes [77,131-135].

Driving is assessed in 3 primary ways: (1) driving simulation, (2) the driving habits questionnaire, and (3) retrospective and prospective state crash records [124]. As mentioned earlier, the driving simulator has been used in earlier studies to document the relationship between functioning in certain neurocognitive domains on particular driving simulator outcomes [13]. Such standardized, performance-based outcomes include: average gross reaction time, percentage of time driving outside of the lane, percentage of time driving over the posted speed limit, and so on.

The driving habits questionnaire [124] is a self-report survey that assesses driving exposure and driving avoidance across varying difficult driving circumstances (eg, driving at night). Driving exposure [124] is assessed with 4 self-reported items: (1) number of days per week driven (0–7), (2) miles driven per week (numeric estimate), (3) miles driven per year (estimated to the nearest 2500 miles), and (4) driving space (the further one has driven from home in the past year). These items can then be standardized (*z*-scored) and summed to form a driving exposure composite score.

Driving avoidance [124] is assessed with 10 self-reported items that ascertain whether participants passed up opportunities to drive in the past 3-month period due to avoiding difficult driving circumstances: (1) driving at night, (2) driving in bad weather, (3) driving alone, (4) driving on interstate highways or expressways, (5) driving in unfamilar places, (6) driving on high traffic roads not including interstates, (7) driving in rush-hour traffic, (8) making lane changes, (9) making left-hand turns across oncoming traffic, and (10) merging into traffic while entering a highway or expressway. Likewise, these items can then be standardized (*z*-scored) and summed to form a driving exposure composite score.

Retrospective and prospective vehicle state crash records are also accessed through the Alabama Department of Transportation (ADOT). As in past studies, using participants' driver's license numbers, a request is made to the ADOT office requesting for accident reports which are publically available records and made available for a small fee. These files contain police reports that describe the circumstances of the accident. Based upon these reports, a determination of whether participants were at fault or not is determined by 2 independent raters; when there is a lack of an agreement, a third rater makes the final determination. Thus, these state crash records can be used to determine what variables are correlated to the number of total crashes, number of at-fault crashes, and number of not-at-fault crashes. The use of actual, real life vehicle crash records provides convergent validity to the other driving measures and is also ecologically valid.

Crash records can be examined both retrospectively and prospectively. Retrospectively, once the entire initial sample's baseline data are collected, participants' driving records can be requested for the 5 years prior to starting our study and examined to determine crash rates and neurocognitive predictors of crashes. Prospectively, once participants have completed the training in our 2-year study, it can be determined through logistic regression and hierarchical regression whether this intervention was effective in reducing the frequency and severity of vehicle crashes. Given the infrequent nature of vehicular crashes, the large sample size of this study will provide insight into whether this intervention is effective in helping adults with HAND maintain safe driving. Although obtaining information on participants' driving exposure and driving avoidance may modify the risk of crashes for some of our participants, their combined influence can be examined over time as these variables are assessed at each time point.

Discussion

Examination of Biomarkers

A unique featue of this study is the incorporation of biomarkers of brain health and brain chemistry through a separate K99 and R00 (K99AG048762) grant mechanism that uses the infrastructure of the parent R01 to examine the relationship between such biomarkers on neurocognitive and everyday functioning. In the neuroscience literature, it is clear that even basic biomarkers such as stress hormones or the amount of HIV virus in the blood can impair certain cognitive functions [136]; thus, measuring such biomarkers may help examine their impact on cognition. And since such biomarkers are known to impact cognitive functioning, the presence of such biomarkers may either facilitate or hinder the training effects of the intervention. Furthermore, studies also show that when people or organisms are exposed to novel stimuli and learning situations, these environmental stimuli can change the neurochemistry of the brain that can be detected through blood draws [137-139]. Thus, these biomarkers are derived from 2 sources. First, since all the participants are recruited from an internal HIV and AIDS clinic, their most current as well as future physiological lab values (eg, triglyceride levels, glucose levels, CD4+ lymphocyte count, HIV viral load) is easily accessed through the clinic's medical database. Logistically, an added feature of this internal access is that the study does not have to expend additional resources of time, money, and participant burden to acquire such information. These basic biomarkers are relevant as they may affect neurocognitive functioning [18,24,140,141] as well as influence (or be influenced by) training gains from the intervention (ie, if a participant is experiencing cognitive problems from elevated triglycerides, then his poorer cognitive functioning may hinder how well he benefits from the training protocol).

Second, blood draws from a subset of participants (approximately 200 who are first to agree to be in this substudy) during the time of the baseline visit are also conducted to collect aliquots of blood to test for various inflammatory biomarkers (eg, IL-6, souble CD14) and neurotrophic factors (eg, insulin-like growth factor), changes in many of which have been associated previously with HAND and HIV(+) patients with neurocognitive decline [142-145]. Again, monitoring these specific biomarkers is equally relevant because they may not only affect neurocognitive functioning [136] but they may also influence training gains from the intervention, and be influenced by the intervention. As mentioned earlier, exposure to novel stimuli has been shown to change brain chemistry[138,139]; thus, participating in this intervention may likewise change brain chemistry which may be detected with blood draws and looking for certain biomarkers. Moreover, positive correlations in changes of these candidate blood biomarkers with respect to our training intervention may suggest their future utility to clinicians for monitoring disease progression, and response to therapy.

Conclusions

This study protocol examining a cognitive remediation program is reflective of other methodologies that examine their benefits over time. As such, this study design lends itself to other types of computerized cognitive remediation programs that are online and utilize computer gaming features to improve particular neurocognitive abilities [75,107]. Other cognitive remediation programs are touted to improve executive functioning, language, memory, attention, and even improve social functioning skills and reduce rumination (eg, cognitive bias modification) [146,147]. This protocol can be easily modified to examine the efficacy of these programs. In fact, with enough resources, these programs can be examined side-by-side and in combination to examine their efficacy over time. Furthermore, other biomarkers and brain imaging techniques could also be applied to examine how these cognitive remediation programs specifically are influenced and even alter brain chemistry and brain morphology [53,148]. Future studies may even examine the influence of such computerized cognitive remediation protocols in delaying or mitigating the effects of disease-related and age-related neurocognitive declines, mild neurocognitive impairment, and dementia.

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Conflicts of Interest

Karlene Ball owns stock in the Visual Awareness Research Group (formerly Visual Awareness, Inc) and Posit Science, Inc, the companies that market the Useful Field of View Test and speed of processing training software. Posit Science acquired Visual Awareness, and Dr Ball continues to collaborate on the design and testing of these assessment and training programs as a member of the Posit Science Scientific Advisory Board.

Multimedia Appendix 1

NIH peer-review feedback.

[PDF File (Adobe PDF File), 126KB - resprot_v6i4e68_app1.PDF]

References

1. Collaboration of Observational HIV Epidemiological Research Europe (COHERE) in EuroCoord, Lewden C, Bouteloup V, De WS, Sabin C, Mocroft A, et al. All-cause mortality in treated HIV-infected adults with CD4 ≥500/mm3 compared with the general population: evidence from a large European observational cohort collaboration. Int J Epidemiol 2012 Apr;41(2):433-445. [doi: 10.1093/ije/dyr164] [Medline: 22493325]
2. Vance DE, Fazeli PL, Moneyham L, Keltner NL, Raper JL. Assessing and treating forgetfulness and cognitive problems in adults with HIV. J Assoc Nurses AIDS Care 2013;24(1 Suppl):S40-S60 [FREE Full text] [doi: 10.1016/j.jana.2012.03.006] [Medline: 23290376]
3. Antinori A, Arendt G, Becker JT, Brew BJ, Byrd DA, Cherner M, et al. Updated research nosology for HIV-associated neurocognitive disorders. Neurology 2007 Oct 30;69(18):1789-1799 [FREE Full text] [doi: 10.1212/01.WNL.0000287431.88658.8b] [Medline: 17914061]
4. Heaton RK, Franklin DR, Ellis RJ, McCutchan JA, Letendre SL, Leblanc S, et al. HIV-associated neurocognitive disorders before and during the era of combination antiretroviral therapy: differences in rates, nature, and predictors. J Neurovirol 2011 Feb;17(1):3-16 [FREE Full text] [doi: 10.1007/s13365-010-0006-1] [Medline: 21174240]
5. Heaton RK, Clifford DB, Franklin DR, Woods SP, Ake C, Vaida F, et al. HIV-associated neurocognitive disorders persist in the era of potent antiretroviral therapy: CHARTER Study. Neurology 2010 Dec 07;75(23):2087-2096 [FREE Full text] [doi: 10.1212/WNL.0b013e318200d727] [Medline: 21135382]
6. United States Senate. Washington, DC: United States Senate Special Committee on Aging; 2013 Sep 18. Older Americans: the changing face of HIV/AIDS in America URL: https://www.aging.senate.gov/hearings/older-americans-the-changing-face-of-hiv/aids-in-america [accessed 2017-03-08] [WebCite Cache ID 6oonPXaaz]
7. Joseph J, Achim CL, Boivin MJ, Brew BJ, Clifford DB, Colosi DA, et al. Global NeuroAIDS roundtable. J Neurovirol 2013 Feb;19(1):1-9 [FREE Full text] [doi: 10.1007/s13365-012-0143-9] [Medline: 23354550]
8. Vance DE, Fazeli PL, Gakumo CA. The impact of neuropsychological performance on everyday functioning between older and younger adults with and without HIV. J Assoc Nurses AIDS Care 2013;24(2):112-125 [FREE Full text] [doi: 10.1016/j.jana.2012.05.002] [Medline: 22943982]
9. Scott JC, Woods SP, Vigil O, Heaton RK, Schweinsburg BC, Ellis RJ, San Diego HIV Neurobehavioral Research Center (HNRC) Group. A neuropsychological investigation of multitasking in HIV infection: implications for everyday functioning. Neuropsychology 2011 Jul;25(4):511-519 [FREE Full text] [doi: 10.1037/a0022491] [Medline: 21401259]
10. Marcotte TD, Lazzaretto D, Scott JC, Roberts E, Woods SP, Letendre S. Visual attention deficits are associated with driving accidents in cognitively-impaired HIV-infected individuals. J Clin Exp Neuropsychol 2006 Jan;28(1):13-28. [doi: 10.1080/13803390490918048] [Medline: 16448973]
11. Vance DE, Wadley VG, Crowe MG, Raper JL, Ball KK. Cognitive and everyday functioning in older and younger adults with and without HIV. Clin Gerontol 2011 Oct;34(5):413-426 [FREE Full text] [doi: 10.1080/07317115.2011.588545] [Medline: 22563140]
12. Vance DE, Fazeli PL, Gakumo CA. The impact of neuropsychological performance on everyday functioning between older and younger adults with and without HIV. J Assoc Nurses AIDS Care 2013;24(2):112-125 [FREE Full text] [doi: 10.1016/j.jana.2012.05.002] [Medline: 22943982]
13. Vance DE, Fazeli PL, Ball DA, Slater LZ, Ross LA. Cognitive functioning and driving simulator performance in middle-aged and older adults with HIV. J Assoc Nurses AIDS Care 2014;25(2):e11-e26 [FREE Full text] [doi: 10.1016/j.jana.2013.12.001] [Medline: 24513104]
14. Valcour V, Paul R, Neuhaus J, Shikuma C. The effects of age and HIV on neuropsychological performance. J Int Neuropsychol Soc 2011 Jan;17(1):190-195 [FREE Full text] [doi: 10.1017/S1355617710001438] [Medline: 21144102]
15. Mindt MR, Miranda C, Arentoft A, Byrd D, Monzones J, Fuentes A, et al. Aging and HIV/AIDS: neurocognitive implications for older HIV-positive Latina/o adults. Behav Med 2014;40(3):116-123. [doi: 10.1080/08964289.2014.914464] [Medline: 25090364]
16. Marcotte TD. Cognitive disorders in the era of combination HIV antiviral treatment. Focus 2008 Sep;23(3):1-5. [Medline: 19062781]

17. Marcotte TD, Deutsch R, McCutchan JA, Moore DJ, Letendre S, Ellis RJ, San Diego HIV Neurobehavioral Research Center (HNRC) Group. Prediction of incident neurocognitive impairment by plasma HIV RNA and CD4 levels early after HIV seroconversion. Arch Neurol 2003 Oct;60(10):1406-1412. [doi: 10.1001/archneur.60.10.1406] [Medline: 14568811]
18. Valcour VG, Shikuma CM, Watters MR, Sacktor NC. Cognitive impairment in older HIV-1-seropositive individuals: prevalence and potential mechanisms. AIDS 2004 Jan 01;18 Suppl 1:S79-S86 [FREE Full text] [Medline: 15075502]
19. Hinkin C, Castellon SA, Hardy DJ. Dual task performance in HIV-1 infection. J Clin Exp Neuropsychol 2000 Feb;22(1):16-24. [doi: 10.1076/1380-3395(200002)22:1;1-8;FT016] [Medline: 10649542]
20. Hinkin CH, Castellon SA, Hardy DJ, Granholm E, Siegle G. Computerized and traditional stroop task dysfunction in HIV-1 infection. Neuropsychology 1999 Apr;13(2):306-316. [Medline: 10353380]
21. Hinkin CH, Hardy DJ, Mason KI, Castellon SA, Lam MN, Stefaniak M, et al. Verbal and spatial working memory performance among HIV-infected adults. J Int Neuropsychol Soc 2002 May;8(4):532-538. [Medline: 12030306]
22. Goodkin K, Wilkie FL, Concha M, Hinkin CH, Symes S, Baldewicz TT, et al. Aging and neuro-AIDS conditions and the changing spectrum of HIV-1-associated morbidity and mortality. J Clin Epidemiol 2001 Dec;54 Suppl 1:S35-S43. [Medline: 11750208]
23. Durvasula RS, Hinkin CH. Neuropsychological Dysfunction among HIV Infected Drug Abusers. Am J Infect Dis 2006;2(2):67-73 [FREE Full text] [Medline: 20467580]
24. Fazeli PL, Marceaux JC, Vance DE, Slater L, Long CA. Predictors of cognition in adults with HIV: implications for nursing practice and research. J Neurosci Nurs 2011 Feb;43(1):36-50 [FREE Full text] [Medline: 21338043]
25. Hardy DJ, Hinkin CH. Reaction time performance in adults with HIV/AIDS. J Clin Exp Neuropsychol 2002 Oct;24(7):912-929. [doi: 10.1076/jcen.24.7.912.8391] [Medline: 12647768]
26. Hardy DJ, Hinkin CH. Reaction time slowing in adults with HIV: results of a meta-analysis using brinley plots. Brain Cogn 2002 Oct;50(1):25-34. [Medline: 12372349]
27. Moore DJ, Letendre SL, Morris S, Umlauf A, Deutsch R, Smith DM, et al. Neurocognitive functioning in acute or early HIV infection. J Neurovirol 2011 Feb;17(1):50-57 [FREE Full text] [doi: 10.1007/s13365-010-0009-y] [Medline: 21165782]
28. Moore DJ, Masliah E, Rippeth JD, Gonzalez R, Carey CL, Cherner M, et al. Cortical and subcortical neurodegeneration is associated with HIV neurocognitive impairment. AIDS 2006 Apr 04;20(6):879-887. [doi: 10.1097/01.aids.0000218552.69834.00] [Medline: 16549972]
29. Wilkie FL, Goodkin K, Khamis I, van Zuilen Maria H, Lee D, Lecusay R, et al. Cognitive functioning in younger and older HIV-1-infected adults. J Acquir Immune Defic Syndr 2003 Jun 01;33 Suppl 2:S93-S105. [Medline: 12853858]
30. Lin F, Chen DD, Vance D, Mapstone M. Trajectories of combined laboratory- and real world-based speed of processing in community-dwelling older adults. J Gerontol B Psychol Sci Soc Sci 2013 May;68(3):364-373 [FREE Full text] [doi: 10.1093/geronb/gbs075] [Medline: 22967505]
31. Vance D. Speed of processing in older adults: a cognitive overview for nursing. J Neurosci Nurs 2009 Dec;41(6):290-297. [Medline: 19998680]
32. Salthouse TA. The processing-speed theory of adult age differences in cognition. Psychol Rev 1996 Jul;103(3):403-428. [Medline: 8759042]
33. Reger M, Welsh R, Razani J, Martin DJ, Boone KB. A meta-analysis of the neuropsychological sequelae of HIV infection. J Int Neuropsychol Soc 2002 Mar;8(3):410-424. [Medline: 11939699]
34. Hardy DJ, Vance DE. The neuropsychology of HIV/AIDS in older adults. Neuropsychol Rev 2009 Jun;19(2):263-272. [doi: 10.1007/s11065-009-9087-0] [Medline: 19247836]
35. Fellows RP, Byrd DA, Morgello S. Effects of information processing speed on learning, memory, and executive functioning in people living with HIV/AIDS. J Clin Exp Neuropsychol 2014;36(8):806-817 [FREE Full text] [doi: 10.1080/13803395.2014.943696] [Medline: 25111120]
36. Doyle KL, Morgan EE, Morris S, Smith DM, Little S, Iudicello JE, Translational Methamphetamine AIDS Research Center (TMARC) Group. Real-world impact of neurocognitive deficits in acute and early HIV infection. J Neurovirol 2013 Dec;19(6):565-573 [FREE Full text] [doi: 10.1007/s13365-013-0218-2] [Medline: 24277439]
37. Wadley V, Okonkwo O, Crowe M, Vance DE, Elgin JM, Ball KK, et al. Mild cognitive impairment and everyday function: an investigation of driving performance. J Geriatr Psychiatry Neurol 2009 Jun;22(2):87-94 [FREE Full text] [doi: 10.1177/0891988708328215] [Medline: 19196629]
38. Clay OJ, Wadley VG, Edwards JD, Roth DL, Roenker DL, Ball KK. Cumulative meta-analysis of the relationship between useful field of view and driving performance in older adults: current and future implications. Optom Vis Sci 2005 Aug;82(8):724-731. [Medline: 16127338]
39. Marcotte TD, Heaton RK, Wolfson T, Taylor MJ, Alhassoon O, Arfaa K, et al. The impact of HIV-related neuropsychological dysfunction on driving behavior. The HNRC Group. J Int Neuropsychol Soc 1999 Nov;5(7):579-592. [Medline: 10645701]
40. Foley J, Gooding AL, Thames AD, Ettenhofer ML, Kim MS, Castellon SA, et al. Visuospatial and attentional abilities predict driving simulator performance among older HIV-infected adults. Am J Alzheimers Dis Other Demen 2013 Mar;28(2):185-194. [doi: 10.1177/1533317512473192] [Medline: 23314403]
41. Reif S, Geonnotti KL, Whetten K. HIV infection and AIDS in the deep south. Am J Public Health 2006 Jun;96(6):970-973. [doi: 10.2105/AJPH.2005.063149] [Medline: 16670228]

42. Chesson HW, Kent CK, Owusu-Edusei K, Leichliter JS, Aral SO. Disparities in sexually transmitted disease rates across the "eight Americas". Sex Transm Dis 2012 Jun;39(6):458-464. [doi: 10.1097/OLQ.0b013e318248e3eb] [Medline: 22592832]
43. Thames A, Magpantay L, Martinez-Maza O, Singer E, Hinkin C, Byrd D, et al. B-85 * genotype, CSF inflammation, and cognitive performance among African Americans and European Americans with HIV-infection. Arch Clin Neuropsychol 2014 Aug 28;29(6):568-569. [doi: 10.1093/arclin/acu038.173]
44. Arentoft A, Byrd D, Monzones J, Coulehan K, Fuentes A, Rosario A, et al. Socioeconomic status and neuropsychological functioning: associations in an ethnically diverse HIV+ cohort. Clin Neuropsychol 2015;29(2):232-254 [FREE Full text] [doi: 10.1080/13854046.2015.1029974] [Medline: 25871409]
45. Vance D, Mugavero M, Willig J, Raper JL, Saag MS. Aging with HIV: a cross-sectional study of comorbidity prevalence and clinical characteristics across decades of life. J Assoc Nurses AIDS Care 2011;22(1):17-25. [doi: 10.1016/j.jana.2010.04.002] [Medline: 20471864]
46. Gebo KA, Justice A. HIV infection in the elderly. Curr Infect Dis Rep 2009 May;11(3):246-254 [FREE Full text] [Medline: 19366568]
47. Vance DE, Fazeli PL, Moneyham L, Keltner NL, Raper JL. Assessing and treating forgetfulness and cognitive problems in adults with HIV. J Assoc Nurses AIDS Care 2013;24(1 Suppl):S40-S60 [FREE Full text] [doi: 10.1016/j.jana.2012.03.006] [Medline: 23290376]
48. Oursler KK, Goulet JL, Leaf DA, Akingicil A, Katzel LI, Justice A, et al. Association of comorbidity with physical disability in older HIV-infected adults. AIDS Patient Care STDS 2006 Nov;20(11):782-791. [doi: 10.1089/apc.2006.20.782] [Medline: 17134352]
49. Goulet JL, Fultz SL, Rimland D, Butt A, Gibert C, Rodriguez-Barradas M, et al. Aging and infectious diseases: do patterns of comorbidity vary by HIV status, age, and HIV severity? Clin Infect Dis 2007 Dec 15;45(12):1593-1601 [FREE Full text] [doi: 10.1086/523577] [Medline: 18190322]
50. Effros RB, Fletcher CV, Gebo K, Halter JB, Hazzard WR, Horne FM, et al. Aging and infectious diseases: workshop on HIV infection and aging: what is known and future research directions. Clin Infect Dis 2008 Aug 15;47(4):542-553 [FREE Full text] [doi: 10.1086/590150] [Medline: 18627268]
51. Mozolic JL, Hayasaka S, Laurienti PJ. A cognitive training intervention increases resting cerebral blood flow in healthy older adults. Front Hum Neurosci 2010;4:16 [FREE Full text] [doi: 10.3389/neuro.09.016.2010] [Medline: 20300200]
52. Lampit A, Hallock H, Valenzuela M. Computerized cognitive training in cognitively healthy older adults: a systematic review and meta-analysis of effect modifiers. PLoS Med 2014 Nov;11(11):e1001756 [FREE Full text] [doi: 10.1371/journal.pmed.1001756] [Medline: 25405755]
53. Mozolic JL, Long AB, Morgan AR, Rawley-Payne M, Laurienti PJ. A cognitive training intervention improves modality-specific attention in a randomized controlled trial of healthy older adults. Neurobiol Aging 2011 Apr;32(4):655-668 [FREE Full text] [doi: 10.1016/j.neurobiolaging.2009.04.013] [Medline: 19428142]
54. Becker JT, Dew MA, Aizenstein HJ, Lopez OL, Morrow L, Saxton J, et al. A pilot study of the effects of internet-based cognitive stimulation on neuropsychological function in HIV disease. Disabil Rehabil 2012;34(21):1848-1852 [FREE Full text] [doi: 10.3109/09638288.2012.667188] [Medline: 22458375]
55. Vance D, Fazeli PL, Ross LA, Wadley VG, Ball KK. Speed of processing training with middle-age and older adults with HIV: a pilot study. J Assoc Nurses AIDS Care 2012;23(6):500-510 [FREE Full text] [doi: 10.1016/j.jana.2012.01.005] [Medline: 22579081]
56. Salthouse TA. Constraints on theories of cognitive aging. Psychon Bull Rev 1996 Sep;3(3):287-299. [doi: 10.3758/BF03210753] [Medline: 24213930]
57. Salthouse T. General and specific speed mediation of adult age differences in memory. J Gerontol B Psychol Sci Soc Sci 1996 Jan;51(1):P30-P42. [Medline: 8548516]
58. Vance DE, Graham MA, Fazeli PL, Heaton K, Moneyham L. An overview of nonpathological geroneuropsychology: implications for nursing practice and research. J Neurosci Nurs 2012 Feb;44(1):43-53 [FREE Full text] [doi: 10.1097/JNN.0b013e31823ae48b] [Medline: 22210304]
59. Vance D, Fazeli PL, Kaur J, Pearce P, McGuinness T. Neuropsychology and cognitive health in healthy older adults: a brief overview for psychiatric nurses. J Psychosoc Nurs Ment Health Serv 2012 Jun;50(6):30-7; quiz 46. [doi: 10.3928/02793695-20120508-03] [Medline: 22589228]
60. Cerella J. Generalized slowing in Brinley plots. J Gerontol 1994 Mar;49(2):P65-P71. [Medline: 8126361]
61. Cerella J, Hale S. The rise and fall in information-processing rates over the life span. Acta Psychol (Amst) 1994 Aug;86(2-3):109-197. [Medline: 7976466]
62. Lindenberger U, Baltes PB. [Cognitive capacity in advanced age: initial results of the Berlin Aging Study]. Z Psychol Z Angew Psychol 1995;203(4):283-317. [Medline: 7483746]
63. Fristoe NM, Salthouse TA, Woodard JL. Examination of age-related deficits on the Wisconsin card sorting test. Neuropsychology 1997 Jul;11(3):428-436. [Medline: 9223147]
64. O'Brien J, Edwards JD, Maxfield ND, Peronto CL, Williams VA, Lister JJ. Cognitive training and selective attention in the aging brain: an electrophysiological study. Clin Neurophysiol 2013 Nov;124(11):2198-2208. [doi: 10.1016/j.clinph.2013.05.012] [Medline: 23770088]

65. Melrose R, Tinaz S, Castelo J, Courtney MG, Stern CE. Compromised fronto-striatal functioning in HIV: an fMRI investigation of semantic event sequencing. Behav Brain Res 2008 Apr 09;188(2):337-347. [doi: 10.1016/j.bbr.2007.11.021] [Medline: 18242723]
66. Schweinsburg BC, Scott JC, Schweinsburg AD, Jacobus J, Theilmann RJ, Frank LR, HIV Neurobehavioral Research Center (HNRC) Group. Altered prefronto-striato-parietal network response to mental rotation in HIV. J Neurovirol 2012 Feb;18(1):74-79 [FREE Full text] [doi: 10.1007/s13365-011-0072-z] [Medline: 22271019]
67. Fabiani M, Friedman D, Cheng JC. Individual differences in P3 scalp distribution in older adults, and their relationship to frontal lobe function. Psychophysiology 1998 Nov;35(6):698-708. [Medline: 9844431]
68. Rebok G, Ball K, Guey LT, Jones RN, Kim H, King JW, et al. Ten-year effects of the advanced cognitive training for independent and vital elderly cognitive training trial on cognition and everyday functioning in older adults. J Am Geriatr Soc 2014 Jan;62(1):16-24 [FREE Full text] [doi: 10.1111/jgs.12607] [Medline: 24417410]
69. Lister J, Besing J, Koehnke J. Effects of age and frequency disparity on gap discrimination. J Acoust Soc Am 2002 Jun;111(6):2793-2800. [Medline: 12083214]
70. Merzenich MM, Jenkins WM, Johnston P, Schreiner C, Miller SL, Tallal P. Temporal processing deficits of language-learning impaired children ameliorated by training. Science 1996 Jan 05;271(5245):77-81. [Medline: 8539603]
71. Wright BA, Buonomano DV, Mahncke HW, Merzenich MM. Learning and generalization of auditory temporal-interval discrimination in humans. J Neurosci 1997 May 15;17(10):3956-3963 [FREE Full text] [Medline: 9133413]
72. Vance D. Implications of positive and negative neuroplasticity on cognition in HIV. Med Sci Monit 2010 Apr;16(4):HY3-HY5. [Medline: 20357724]
73. Vance D. Aging with HIV: clinical considerations for an emerging population. Am J Nurs 2010 Mar;110(3):42-7; quiz 48 [FREE Full text] [doi: 10.1097/01.NAJ.0000368952.80634.42] [Medline: 20179457]
74. Vance D, Heaton K, Fazeli P, Ackerman M. Aging, speed of processing training, and everyday functioning: implications for practice and research. Activ Adapt Aging 2010 Nov 30;34(4):276-291. [doi: 10.1080/01924788.2010.523867]
75. Vance D, Dawson J, Wadley V, Edwards J, Roenker D, Rizzo M, et al. The accelerate study: The longitudinal effect of speed of processing training on cognitive performance of older adults. Rehabil Psychol 2007;52(1):89-96. [doi: 10.1037/0090-5550.52.1.89]
76. Edwards JD, Wadley VG, Myers RS, Roenker DL, Cissell GM, Ball KK. Transfer of a speed of processing intervention to near and far cognitive functions. Gerontology 2002 Aug 16;48(5):329-340. [doi: 10.1159/000065259] [Medline: 12169801]
77. Edwards JD, Myers C, Ross LA, Roenker DL, Cissell GM, McLaughlin AM, et al. The longitudinal impact of cognitive speed of processing training on driving mobility. Gerontologist 2009 Aug;49(4):485-494 [FREE Full text] [doi: 10.1093/geront/gnp042] [Medline: 19491362]
78. Friedman C, McGwin G, Ball KK, Owsley C. Association between higher order visual processing abilities and a history of motor vehicle collision involvement by drivers ages 70 and over. Invest Ophthalmol Vis Sci 2013 Jan 28;54(1):778-782 [FREE Full text] [doi: 10.1167/iovs.12-11249] [Medline: 23307969]
79. Edwards J, Ross LA, Ackerman ML, Small BJ, Ball KK, Bradley S, et al. Longitudinal predictors of driving cessation among older adults from the ACTIVE clinical trial. J Gerontol B Psychol Sci Soc Sci 2008 Jan;63(1):P6-12. [Medline: 18332196]
80. Owsley C, Ball K, McGwin G, Sloane ME, Roenker DL, White MF, et al. Visual processing impairment and risk of motor vehicle crash among older adults. JAMA 1998 Apr 08;279(14):1083-1088. [Medline: 9546567]
81. Edwards JD, Wadley VG, Vance DE, Wood K, Roenker DL, Ball KK. The impact of speed of processing training on cognitive and everyday performance. Aging Ment Health 2005 May;9(3):262-271. [doi: 10.1080/13607860412331336788] [Medline: 16019280]
82. Roenker DL, Cissell GM, Ball KK, Wadley VG, Edwards JD. Speed-of-processing and driving simulator training result in improved driving performance. Hum Factors 2003;45(2):218-233. [Medline: 14529195]
83. Willis SL, Tennstedt SL, Marsiske M, Ball K, Elias J, Koepke KM, et al. Long-term effects of cognitive training on everyday functional outcomes in older adults. JAMA 2006 Dec 20;296(23):2805-2814 [FREE Full text] [doi: 10.1001/jama.296.23.2805] [Medline: 17179457]
84. Wolinsky F, Mahncke H, Vander WM, Martin R, Unverzagt FW, Ball KK, et al. Speed of processing training protects self-rated health in older adults: enduring effects observed in the multi-site ACTIVE randomized controlled trial. Int Psychogeriatr 2010 May;22(3):470-478 [FREE Full text] [doi: 10.1017/S1041610209991281] [Medline: 20003628]
85. Wolinsky FD, Vander WM, Martin R, Unverzagt FW, Willis SL, Marsiske M, et al. Does cognitive training improve internal locus of control among older adults? J Gerontol B Psychol Sci Soc Sci 2010 Sep;65(5):591-598 [FREE Full text] [doi: 10.1093/geronb/gbp117] [Medline: 20008028]
86. Collins E, Wagner C, Walmsley S. Psychosocial impact of the lipodystrophy syndrome in HIV infection. AIDS Read 2000 Sep;10(9):546-550. [Medline: 11019453]
87. Wolinsky FD, Unverzagt FW, Smith DM, Jones R, Wright E, Tennstedt SL. The effects of the ACTIVE cognitive training trial on clinically relevant declines in health-related quality of life. J Gerontol B Psychol Sci Soc Sci 2006 Sep;61(5):S281-S287. [Medline: 16960242]

88. Wolinsky FD, Unverzagt FW, Smith DM, Jones R, Stoddard A, Tennstedt SL. The ACTIVE cognitive training trial and health-related quality of life: protection that lasts for 5 years. J Gerontol A Biol Sci Med Sci 2006 Dec;61(12):1324-1329. [Medline: 17234829]
89. Evans S, Ferrando SJ, Rabkin JG, Fishman B. Health locus of control, distress, and utilization of protease inhibitors among HIV-positive men. J Psychosom Res 2000 Aug;49(2):157-162. [Medline: 11068061]
90. Wolinsky FD, Vander WM, Martin R, Unverzagt FW, Ball KK, Jones RN, et al. The effect of speed-of-processing training on depressive symptoms in ACTIVE. J Gerontol A Biol Sci Med Sci 2009 Apr;64(4):468-472 [FREE Full text] [doi: 10.1093/gerona/gln044] [Medline: 19181719]
91. Morgan EE, Iudicello JE, Weber E, Duarte NA, Riggs PK, Delano-Wood L, HIV Neurobehavioral Research Program (HNRP) Group. Synergistic effects of HIV infection and older age on daily functioning. J Acquir Immune Defic Syndr 2012 Nov 01;61(3):341-348 [FREE Full text] [doi: 10.1097/QAI.0b013e31826bfc53] [Medline: 22878422]
92. Slater LZ, Moneyham L, Vance DE, Raper JL, Mugavero MJ, Childs G. Support, stigma, health, coping, and quality of life in older gay men with HIV. J Assoc Nurses AIDS Care 2013;24(1):38-49. [doi: 10.1016/j.jana.2012.02.006] [Medline: 22687445]
93. Moore R, Fazeli PL, Jeste DV, Moore DJ, Grant I, Woods SP, HIV Neurobehavioral Research Program (HNRP) Group. Successful cognitive aging and health-related quality of life in younger and older adults infected with HIV. AIDS Behav 2014 Jun;18(6):1186-1197 [FREE Full text] [doi: 10.1007/s10461-014-0743-x] [Medline: 24633788]
94. Vance DE. Self-rated emotional health in adults with and without HIV. Psychol Rep 2006 Feb;98(1):106-108. [doi: 10.2466/pr0.98.1.106-108] [Medline: 16673959]
95. Vance DE, Moneyham L, Farr KF. Suicidal ideation in adults aging with HIV: neurological and cognitive considerations. J Psychosoc Nurs Ment Health Serv 2008 Nov;46(11):33-38. [Medline: 19051576]
96. Kelly B, Raphael B, Judd F, Perdices M, Kernutt G, Burnett P, et al. Suicidal ideation, suicide attempts, and HIV infection. Psychosomatics 1998;39(5):405-415. [doi: 10.1016/S0033-3182(98)71299-X] [Medline: 9775697]
97. Nannis ED, Patterson TL, Semple SJ. Coping with HIV disease among seropositive women: psychosocial correlates. Women Health 1997;25(1):1-22. [doi: 10.1300/J013v25n01_01] [Medline: 9253135]
98. Vance DE, Moneyham L, Fordham P, Struzick TC. A model of suicidal ideation in adults aging with HIV. J Assoc Nurses AIDS Care 2008;19(5):375-384. [doi: 10.1016/j.jana.2008.04.011] [Medline: 18762145]
99. Vance D, Humphrey SC, Nicholson WC, Jablonski-Jaudon R. Can speed of processing training ameliorate depressive symptomatology in adults with HIV? Ann Depress Anxiety 2014 Sep 04;1(3):4 [FREE Full text] [Medline: 26280022]
100. Ackerman ML, Crowe M, Vance DE, Wadley VG, Owsley C, Ball KK. The impact of feedback on self-rated driving ability and driving self-regulation among older adults. Gerontologist 2011 Jun;51(3):367-378 [FREE Full text] [doi: 10.1093/geront/gnq082] [Medline: 21071621]
101. Hinkin CH, Hardy DJ, Mason KI, Castellon SA, Durvasula RS, Lam MN, et al. Medication adherence in HIV-infected adults: effect of patient age, cognitive status, and substance abuse. AIDS 2004 Jan 01;18 Suppl 1:S19-S25 [FREE Full text] [Medline: 15075494]
102. Vance DE, Wadley VG, Crowe MG, Raper JL, Ball KK. Cognitive and everyday functioning in older and younger adults with and without HIV. Clin Gerontol 2011 Oct;34(5):413-426 [FREE Full text] [doi: 10.1080/07317115.2011.588545] [Medline: 22563140]
103. Scott J, Woods SP, Carey CL, Weber E, Bondi MW, Grant I, HIV Neurobehavioral Research Center (HNRC) Group. Neurocognitive consequences of HIV infection in older adults: an evaluation of the “cortical” hypothesis. AIDS Behav 2011 Aug;15(6):1187-1196 [FREE Full text] [doi: 10.1007/s10461-010-9815-8] [Medline: 20865313]
104. Gandhi NS, Moxley RT, Creighton J, Roosa HV, Skolasky RL, Selnes OA, et al. Comparison of scales to evaluate the progression of HIV-associated neurocognitive disorder. HIV Ther 2010 May;4(3):371-379 [FREE Full text] [doi: 10.2217/hiv.10.23] [Medline: 20824119]
105. Valcour V, Shikuma C, Shiramizu B, Watters M, Poff P, Selnes O, et al. Higher frequency of dementia in older HIV-1 individuals: the Hawaii aging with HIV-1 cohort. Neurology 2004 Sep 14;63(5):822-827 [FREE Full text] [Medline: 15365130]
106. Valcour V, Shikuma C, Shiramizu B, Watters M, Poff P, Selnes OA, et al. Age, apolipoprotein E4, and the risk of HIV dementia: the Hawaii aging with HIV cohort. J Neuroimmunol 2004 Dec;157(1-2):197-202. [doi: 10.1016/j.jneuroim.2004.08.029] [Medline: 15579298]
107. Ball K, Berch DB, Helmers KF, Jobe JB, Leveck MD, Marsiske M, Advanced Cognitive Training for IndependentVital Elderly Study Group. Effects of cognitive training interventions with older adults: a randomized controlled trial. JAMA 2002 Nov 13;288(18):2271-2281 [FREE Full text] [Medline: 12425704]
108. Ball K, Ross LA, Roth DL, Edwards JD. Speed of processing training in the ACTIVE study. J Aging Health 2013 Dec;25(8_suppl):65S-84S. [doi: 10.1177/0898264312470167] [Medline: 24385640]
109. Wadley VG, Benz RL, Ball KK, Roenker DL, Edwards JD, Vance DE. Development and evaluation of home-based speed-of-processing training for older adults. Arch Phys Med Rehabil 2006 Jun;87(6):757-763. [doi: 10.1016/j.apmr.2006.02.027] [Medline: 16731209]

110. Blackstone K, Moore DJ, Franklin DR, Clifford DB, Collier AC, Marra CM, et al. Defining neurocognitive impairment in HIV: deficit scores versus clinical ratings. Clin Neuropsychol 2012;26(6):894-908 [FREE Full text] [doi: 10.1080/13854046.2012.694479] [Medline: 22708483]
111. Blackstone K, Moore DJ, Heaton RK, Franklin DR, Woods SP, Clifford DB, CNS HIV Antiretroviral Therapy Effects Research (CHARTER) Group. Diagnosing symptomatic HIV-associated neurocognitive disorders: self-report versus performance-based assessment of everyday functioning. J Int Neuropsychol Soc 2012 Jan;18(1):79-88 [FREE Full text] [doi: 10.1017/S135561771100141X] [Medline: 22114912]
112. Carey CL, Woods SP, Gonzalez R, Conover E, Marcotte TD, Grant I, et al. Predictive validity of global deficit scores in detecting neuropsychological impairment in HIV infection. J Clin Exp Neuropsychol 2004 May;26(3):307-319. [doi: 10.1080/13803390490510031] [Medline: 15512922]
113. Carey CL, Woods SP, Rippeth JD, Gonzalez R, Moore DJ, Marcotte TD, et al. Initial validation of a screening battery for the detection of HIV-associated cognitive impairment. Clin Neuropsychol 2004 May;18(2):234-248. [doi: 10.1080/13854040490501448] [Medline: 15587671]
114. Woods SP, Moore DJ, Weber E, Grant I. Cognitive neuropsychology of HIV-associated neurocognitive disorders. Neuropsychol Rev 2009 Jun;19(2):152-168 [FREE Full text] [doi: 10.1007/s11065-009-9102-5] [Medline: 19462243]
115. Woods SP, Scott JC, Dawson MS, Morgan EE, Carey CL, Heaton RK, HIV Neurobehavioral Research Center (HNRC) Group. Construct validity of Hopkins verbal learning test-revised component process measures in an HIV-1 sample. Arch Clin Neuropsychol 2005 Dec;20(8):1061-1071 [FREE Full text] [doi: 10.1016/j.acn.2005.06.007] [Medline: 16198529]
116. Woods SP, Scott JC, Conover E, Marcotte TD, Heaton RK, Grant I, HIV Neurobehavioral Research Center Group. Test-retest reliability of component process variables within the Hopkins Verbal Learning Test-Revised. Assessment 2005 Mar;12(1):96-100. [doi: 10.1177/1073191104270342] [Medline: 15695747]
117. Woods SP, Childers M, Ellis RJ, Guaman S, Grant I, Heaton RK, HIV Neurobehavioral Research Center (HNRC) Group. A battery approach for measuring neuropsychological change. Arch Clin Neuropsychol 2006 Jan;21(1):83-89 [FREE Full text] [doi: 10.1016/j.acn.2005.07.008] [Medline: 16169705]
118. Woods SP, Rippeth JD, Frol AB, Levy JK, Ryan E, Soukup VM, et al. Interrater reliability of clinical ratings and neurocognitive diagnoses in HIV. J Clin Exp Neuropsychol 2004 Sep;26(6):759-778. [doi: 10.1080/13803390490509565] [Medline: 15370374]
119. Wilkinson G. Minddisorders. Wilmington, DE: Jastak Association; 1993. Wide Range Achievement Test–Revision 3 URL: http://www.minddisorders.com/Py-Z/Wide-Range-Achievement-Test.html#ixzz4am3tf8p2 [accessed 2017-04-18] [WebCite Cache ID 6poDgS7ak]
120. Edwards JD, Vance DE, Wadley VG, Cissell GM, Roenker DL, Ball KK. Reliability and validity of useful field of view test scores as administered by personal computer. J Clin Exp Neuropsychol 2005 Jul;27(5):529-543. [doi: 10.1080/13803390490515432] [Medline: 16019630]
121. Tombaugh TN. A comprehensive review of the paced auditory serial addition test (PASAT). Arch Clin Neuropsychol 2006 Jan;21(1):53-76 [FREE Full text] [doi: 10.1016/j.acn.2005.07.006] [Medline: 16290063]
122. Rasmusson DX, Bylsma FW, Brandt J. Stability of performance on the Hopkins Verbal Learning Test. Arch Clin Neuropsychol 1995 Jan;10(1):21-26 [FREE Full text] [Medline: 14588448]
123. Lezak M. Neuropsychological Assessment. New York: Oxford University Press; 1995.
124. Vance DE, Roenker DL, Cissell GM, Edwards JD, Wadley VG, Ball KK. Predictors of driving exposure and avoidance in a field study of older drivers from the state of Maryland. Accid Anal Prev 2006 Jul;38(4):823-831. [doi: 10.1016/j.aap.2006.02.008] [Medline: 16545765]
125. Ball K, Edwards JD, Ross LA. The impact of speed of processing training on cognitive and everyday functions. J Gerontol B Psychol Sci Soc Sci 2007 Jun;62 Spec No 1:19-31. [Medline: 17565162]
126. Owsley C, McGwin G, Sloane ME, Stalvey BT, Wells J. Timed instrumental activities of daily living tasks: relationship to visual function in older adults. Optom Vis Sci 2001 May;78(5):350-359. [Medline: 11384013]
127. Owsley C, Sloane M, McGwin G, Ball K. Timed instrumental activities of daily living tasks: relationship to cognitive function and everyday performance assessments in older adults. Gerontology 2002;48(4):254-265. [Medline: 12053117]
128. Sheehan TJ, Fifield J, Reisine S, Tennen H. The measurement structure of the Center for Epidemiologic Studies Depression Scale. J Pers Assess 1995 Jun;64(3):507-521. [doi: 10.1207/s15327752jpa6403_9] [Medline: 7760258]
129. Clark CH, Mahoney JS, Clark DJ, Eriksen LR. Screening for depression in a hepatitis C population: the reliability and validity of the Center for Epidemiologic Studies Depression Scale (CES-D). J Adv Nurs 2002 Nov;40(3):361-369. [Medline: 12383188]
130. Brazier JE, Harper R, Jones NM, O'Cathain A, Thomas KJ, Usherwood T, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. BMJ 1992 Jul 18;305(6846):160-164 [FREE Full text] [Medline: 1285753]
131. McManus B, Cox MK, Vance DE, Stavrinos D. Predicting motor vehicle collisions in a driving simulator in young adults using the useful field of view assessment. Traffic Inj Prev 2015;16(8):818-823 [FREE Full text] [doi: 10.1080/15389588.2015.1027339] [Medline: 25794266]

132. Ross LA, Edwards JD, O'Connor ML, Ball KK, Wadley VG, Vance DE. The transfer of cognitive speed of processing training to older adults' driving mobility across 5 years. J Gerontol B Psychol Sci Soc Sci 2016 Jan;71(1):87-97. [doi: 10.1093/geronb/gbv022] [Medline: 25878053]
133. Roenker DL, Cissell GM, Ball KK, Wadley VG, Edwards JD. Speed-of-processing and driving simulator training result in improved driving performance. Hum Factors 2003;45(2):218-233. [Medline: 14529195]
134. Ball KK, Roenker DL, Wadley VG, Edwards JD, Roth DL, McGwin G, et al. Can high-risk older drivers be identified through performance-based measures in a Department of Motor Vehicles setting? J Am Geriatr Soc 2006 Jan;54(1):77-84. [doi: 10.1111/j.1532-5415.2005.00568.x] [Medline: 16420201]
135. Ross LA, Clay OJ, Edwards JD, Ball KK, Wadley VG, Vance DE, et al. Do older drivers at-risk for crashes modify their driving over time? J Gerontol B Psychol Sci Soc Sci 2009 Mar;64(2):163-170 [FREE Full text] [doi: 10.1093/geronb/gbn034] [Medline: 19196692]
136. Vance DE, Randazza J, Fogger S, Slater LZ, Humphrey SC, Keltner NL. An overview of the biological and psychosocial context surrounding neurocognition in HIV. J Am Psychiatr Nurses Assoc 2014;20(2):117-124. [doi: 10.1177/1078390314527549] [Medline: 24717830]
137. Diamond M. An optimistic view of the aging brain. In: Biomedical Advances in Aging. Boston, MA: GWUMC Department of Biochemistry Annual Spring Symposia; 1990:441-449.
138. Kobayashi S, Ohashi Y, Ando S. Effects of enriched environments with different durations and starting times on learning capacity during aging in rats assessed by a refined procedure of the Hebb-Williams maze task. J Neurosci Res 2002 Nov 01;70(3):340-346. [doi: 10.1002/jnr.10442] [Medline: 12391594]
139. Vance DE, McDougall GJ, Wilson N, Debiasi MO, Cody SL. Cognitive consequences of aging with HIV: implications for neuroplasticity and rehabilitation. Top Geriatr Rehabil 2014 Jan;30(1):35-45 [FREE Full text] [doi: 10.1097/TGR.0000000000000002] [Medline: 24817785]
140. Yaffe K, Vittinghoff E, Pletcher MJ, Hoang TD, Launer LJ, Whitmer R, et al. Early adult to midlife cardiovascular risk factors and cognitive function. Circulation 2014 Apr 15;129(15):1560-1567 [FREE Full text] [doi: 10.1161/CIRCULATIONAHA.113.004798] [Medline: 24687777]
141. Valcour VG, Sacktor NC, Paul RH, Watters MR, Selnes OA, Shiramizu BT, et al. Insulin resistance is associated with cognition among HIV-1-infected patients: the Hawaii Aging With HIV cohort. J Acquir Immune Defic Syndr 2006 Dec 01;43(4):405-410. [doi: 10.1097/01.qai.0000243119.67529.f5] [Medline: 17099311]
142. Suh H, Lo Y, Choi N, Letendre S, Lee SC. Insulin-like growth factors and related proteins in plasma and cerebrospinal fluids of HIV-positive individuals. J Neuroinflammation 2015 Apr 15;12:72 [FREE Full text] [doi: 10.1186/s12974-015-0288-6] [Medline: 25890304]
143. Sun B, Abadjian L, Rempel H, Calosing C, Rothlind J, Pulliam L. Peripheral biomarkers do not correlate with cognitive impairment in highly active antiretroviral therapy-treated subjects with human immunodeficiency virus type 1 infection. J Neurovirol 2010 Mar;16(2):115-124. [doi: 10.3109/13550280903559789] [Medline: 20307252]
144. Sattler FR, He J, Letendre S, Wilson C, Sanders C, Heaton R, et al. Abdominal obesity contributes to neurocognitive impairment in HIV-infected patients with increased inflammation and immune activation. J Acquir Immune Defic Syndr 2015 Mar 01;68(3):281-288 [FREE Full text] [doi: 10.1097/QAI.0000000000000458] [Medline: 25469522]
145. Lake JE, Vo QT, Jacobson LP, Sacktor N, Miller EN, Post WS, et al. Adiponectin and interleukin-6, but not adipose tissue, are associated with worse neurocognitive function in HIV-infected men. Antivir Ther 2015;20(2):235-244 [FREE Full text] [doi: 10.3851/IMP2952] [Medline: 25810377]
146. McIntosh RC, Tartar JL, Widmayer S, Rosselli M. Negative attention bias and processing deficits during the cognitive reappraisal of unpleasant emotions in HIV+ women. J Neuropsychiatry Clin Neurosci 2015;27(1):e32-e39. [doi: 10.1176/appi.neuropsych.13090222] [Medline: 25541865]
147. Vance DE, McNees P, Meneses K. Technology, cognitive remediation, and nursing: directions for successful cognitive aging. J Gerontol Nurs 2009 Feb;35(2):50-56. [Medline: 19263921]
148. Lampit A, Hallock H, Suo C, Naismith SL, Valenzuela M. Cognitive training-induced short-term functional and long-term structural plastic change is related to gains in global cognition in healthy older adults: a pilot study. Front Aging Neurosci 2015;7:14 [FREE Full text] [doi: 10.3389/fnagi.2015.00014] [Medline: 25805989]

Abbreviations

ACTIVE: advanced congnitive training in vital elderly
AIDS: acquired immunodeficiency syndrome
cART: combination antiretroviral therapy
HAND: HIV-associated neurocognitive disorders
HIV: human immunodeficiency virus
RCT: randomized controlled trial

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Protocol

Evaluation of a Web-Based Tailored Nursing Intervention (TAVIE en m@rche) Aimed at Increasing Walking After an Acute Coronary Syndrome: A Multicenter Randomized Controlled Trial Protocol

John William Kayser[1,2], RN, PhD (c); Sylvie Cossette[1,2], RN, PhD; José Côté[1,3], RN, PhD; Anne Bourbonnais[1,4], RN, PhD; Margaret Purden[5,6], RN, PhD; Martin Juneau[2], MD; Jean-Francois Tanguay[2], MD; Marie-Josée Simard[7], RN, MSc; Jocelyn Dupuis[2], MD, PhD; Jean G Diodati[8], MD; Jean-Francois Tremblay[9], MD; Marc-André Maheu-Cadotte[1,2], RN, BSc; Daniel Cournoyer[10], MSc

[1]Université de Montréal, Faculty of Nursing, Montréal, QC, Canada
[2]Montreal Heart Institute Research Center and Université de Montréal, Montréal, QC, Canada
[3]Research Center of the Centre Hospitalier de l'Université de Montréal, Montréal, QC, Canada
[4]Research Center of the Institut universitaire de gériatrie de Montréal, Montréal, QC, Canada
[5]McGill University, Ingram School of Nursing, Montréal, QC, Canada
[6]Jewish General Hospital Centre for Nursing Research, Montréal, QC, Canada
[7]Integrated Health and Social Services Centres, l'Est de l'Île de Montréal, Montréal, QC, Canada
[8]Hôpital du Sacré-Cœur de Montréal, Montréal, QC, Canada
[9]Hôpital Maisonneuve-Rosemont, Montréal, QC, Canada
[10]Montreal Health Innovations Coordinating Center, Montréal, QC, Canada

Corresponding Author:
John William Kayser, RN, PhD (c)
Montreal Heart Institute Research Center and Université de Montréal
5000, rue Bélanger, Room S-2490
Montréal, QC, H1T 1C8
Canada
Phone: 1 514 376 3330 ext 4026
Fax: 1 514 593 2595
Email: john.kayser@umontreal.ca

Abstract

Background: Despite the health benefits of increasing physical activity in the secondary prevention of acute coronary syndrome (ACS), up to 60% of ACS patients are insufficiently active. Evidence supporting the effect of Web-based interventions on increasing physical activity outcomes in ACS patients is growing. However, randomized controlled trials (RCTs) using Web-based technologies that measured objective physical activity outcomes are sparse.

Objective: Our aim is to evaluate in insufficiently active ACS patients, the effect of a fully automated, Web-based tailored nursing intervention (TAVIE en m@rche) on increasing steps per day.

Methods: A parallel two-group multicenter RCT (target N=148) is being conducted in four major teaching hospitals in Montréal, Canada. An experimental group receiving the 4-week TAVIE en m@rche intervention plus a brief "booster" at 8 weeks, is compared with the control group receiving hyperlinks to publicly available websites. TAVIE en m@rche is based on the Strengths-Based Nursing Care orientation to nursing practice and the Self-Determination Theory of human motivation. The intervention is centered on videos of a nurse who delivers the content tailored to baseline levels of self-reported autonomous motivation, perceived competence, and walking behavior. Participants are recruited in hospital and are eligible if they report access to a computer and report less than recommended physical activity levels 6 months before hospitalization. Most outcome data are collected online at baseline, and 5 and 12 weeks postrandomization. The primary outcome is change in accelerometer-measured steps per day between randomization and 12 weeks. The secondary outcomes include change in steps per day between randomization and 5 weeks, and change in self-reported energy expenditure for walking and moderate to vigorous physical activity between randomization, and 5 and 12 weeks. Theoretical outcomes are the mediating role of self-reported perceived autonomy support, autonomous and controlled motivations, perceived competence, and barrier self-efficacy on steps

per day. Clinical outcomes are quality of life, smoking, medication adherence, secondary prevention program attendance, health care utilization, and angina frequency. The potential moderating role of sex will also be explored. Analysis of covariance models will be used with covariates such as sex, age, fatigue, and depression symptoms. Allocation sequence is concealed, and blinding will be implemented during data analysis.

Results: Recruitment started March 30, 2016. Data analysis is planned for November 2017.

Conclusions: Finding alternative interventions aimed at increasing the adoption of health behavior changes such as physical activity in the secondary prevention of ACS is clearly needed. Our RCT is expected to help support the potential efficacy of a fully automated, Web-based tailored nursing intervention on the objective outcome of steps per day in an ACS population. If this RCT is successful, and after its implementation as part of usual care, TAVIE en m@rche could help improve the health of ACS patients at large.

Trial Registration: ClinicalTrials.gov NCT02617641; https://clinicaltrials.gov/ct2/show/NCT02617641 (Archived by WebCite at http://www.webcitation.org/6pNNGndRa)

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KEYWORDS

acute coronary syndrome; secondary prevention; physical activity; walking; Internet; computer-tailored; eHealth; Strengths-Based Nursing Care; Self-Determination Theory; nursing intervention

Introduction

Acute coronary syndromes (ACS) are among the leading causes of coronary artery disease mortality and are among the top reasons for health care utilization in North America [1-3] and worldwide [4]. Physical activity is one behavior associated with several health benefits in ACS patients, including reduced mortality and health care utilization. Accumulating an equivalent of 150 minutes per week of moderate intensity physical activity is associated with reduced all-cause [5-7] and cardiac mortality risk [7] compared with lower levels of physical activity. Evidence from cohort data suggests that all-cause mortality risk can be reduced by accumulating half of the recommendation compared with zero minutes, and further reductions are obtained as physical activity increases [8], which may also be applicable to ACS populations. Other health benefits of increased physical activity in ACS include improved quality of life [9], reduced cardiac risk factors such as dyslipidemia and hypertension, and reduced health care utilization such as hospitalizations [10]. Moreover, positive change in one health behavior, such as an increase in physical activity, may increase overall confidence and serve as a gateway to changing other health behaviors [11], such as increased smoking cessation, healthy diet, medication adherence, or attendance in a cardiac secondary prevention program. Therefore, these multiple health benefits place increased physical activity as a cornerstone in the secondary prevention of ACS [10]. Despite these benefits, between 40% and 60% of patients were insufficiently active after an ACS event [5,6,12].

Increased physical activity is promoted in traditional secondary prevention programs that consist of face-to-face or phone health behavior change counseling, which may range from brief to intensive counseling, and most include supervised exercise in affiliated hospital settings [13]. However, only 22%-30% of cardiac patients attend face-to-face secondary prevention programs [14,15]. Barriers include the difficulty of accessing these programs among those living in remote locations where secondary prevention programs are not offered, traveling to meetings, or reaching those who lack motivation or are unwilling to participate in these programs. Therefore, alternative ways of delivering these programs are being examined in research, including use of the Web [13].

Web-based interventions aimed at improving health behaviors have been tested mostly in general adult populations. These interventions include modes of delivery such as online text, videos, and discussion forums, and include other modes complementary to websites such as email and text message [16]. A meta-analysis of randomized controlled trials (RCTs) and quasi-experimental studies in mainly general adult populations or adults with cardiac risk factors found a significantly greater effect on physical activity outcomes in Web-based interventions compared with usual care control groups that were not Web-based (d=0.14, P<.001) [17]. Although intervention effects were small, a greater effect was found in studies that included only insufficiently active participants compared with those that included any level of physical activity (d=0.37 vs 0.12, respectively, P<.05) [17].

Web-based tailored interventions are expected to increase the relevancy of and attention to the information delivered, which in turn is expected to improve effects on health behavior change [18,19]. Tailoring can be static, such that tailored messages are provided based on a single baseline assessment, or dynamic, such that tailored messages are provided based on multiple assessments from baseline to follow-up [20]. Although a meta-analysis of RCTs and quasi-experimental studies in mainly general adult populations or adults with cardiac risk factors found no differences between tailored versus non-tailored interventions on physical activity outcomes, the authors found a significant effect in favor of tailoring (static or dynamic) on smoking cessation and healthy diet outcomes [21]. Therefore, increased physical activity in Web-based interventions may not depend only on tailoring. Perhaps the combination of components within Web-based tailored interventions matters, such as the variables on which tailoring was based (eg, motivation and confidence), modes of delivery used (eg, combining online text, videos, email, and others), level of intervention intensity delivered, and target population

characteristics. Therefore, further research is needed to test innovative combinations of these components in tailored interventions to influence greater increases in physical activity.

In ACS patients, a Cochrane review found some evidence in eight RCTs to support the effect on increased physical activity outcomes in favor of Web-based interventions (tailored or not) compared with usual care [22]. However, heterogeneity between these RCTs prevented a meta-analysis on physical activity outcomes [22]. Among these eight RCTs, one was a pilot [23], two were not powered on physical activity outcomes [24,25], and one was powered on a self-reported physical activity outcome, but results were limited by the majority of participants dropping out [26]. Only four RCTs were full-sized and powered on objective physical activity outcomes [27-30], among which, two tested tailored interventions [27,28]. Both found significantly greater levels in the primary outcome of steps per day in favor of the tailored experimental groups [27,28]. These data suggest that in ACS populations, the effects of tailored interventions on steps per day outcomes are promising.

The other two RCTs tested nontailored interventions measuring the primary outcome of exercise capacity compared with usual care [29,30]. One RCT found a significantly greater increase in a proxy outcome of exercise capacity, maximal time on treadmill, in favor of the experimental group [29]. In contrast, the other RCT found no difference between groups in treadmill-measured peak oxygen uptake, despite finding significantly greater increases in a subjective secondary outcome of self-reported physical activity in favor of the experimental group [30]. Considering these four RCTs, the content of the Web-based interventions tested were sufficient to increase steps per day [27,28] and maximal time on treadmill [29], but the exercise intensity was insufficient to increase peak oxygen uptake [30]. No RCTs tested Web-based interventions, with or without tailoring, in ACS patients performing insufficient physical activity. The paucity of strong evidence highlights the need for future full-sized RCTs testing Web-based tailored interventions on objective physical activity outcomes in ACS populations.

Theoretical Framework

We designed the fully automated, Web-based tailored nursing intervention TAVIE en m@rche in French. “TA VIE” means *your life*, and “en marche” means *walking* as the intervention is focused on increasing walking behavior in one’s daily life after an ACS-related hospitalization. The tailored content of TAVIE en m@rche is presented to participants by prerecorded videos of a nurse. We used Strengths-Based Nursing Care (SBNC) integrated with Self-Determination Theory (SDT) as the intervention’s theoretical framework. SBNC describes an orientation to nursing practice or a “way of being” that is manifested through person-centered, holistic, knowledgeable, and compassionate nursing care [31]. SBNC is driven by eight values that focus on “understanding the whole, … and understanding how strengths and weaknesses interact to promote health, and healing” (p. 120) [31]: (1) health and healing refers to creating and restoring persons’ sense of wholeness in all domains of human functioning, (2) uniqueness of the person refers to understanding unique experiences and strengths, (3) holism and embodiment refers to understanding the complexities underlying the relationships among the mind, brain, and other body systems, (4) objective/subjective reality and created meaning refers to understanding along with objective observations, subjective realities through created meanings of persons’ experiences, (5) self-determination refers to respecting persons’ right to a life grounded in volition and free will, (6) person and environment are integral refers to understanding how persons’ environments influence health and healing, (7) learning, readiness, and timing refers to being sensitive to readiness and timing when engaging patients in an active learning or change process, and (8) collaborative partnership between nurse and person refers to both nurse and patient sharing knowledge and strategies that foster health and healing.

Self-determination, one of the eight SBNC values, is particularly relevant in nursing care, and in human motivation to adopt health behavior changes. This value was drawn from literature on self-determination including past works on the SDT of human motivation [32]. Empirical work in SDT applied in health care settings has presented two models [33]. The first model suggests that improvements in physical and mental health can be explained by the satisfaction of the psychological needs of autonomy, competence, and relatedness [33]. However, our Web-based intervention that has a minimal focus on encouraging social support from others may not be powerful enough to influence the construct of relatedness, which refers to the “feeling of being respected, understood, and cared for by others” (p. 327 [33]), such as exercise companions. Therefore, the second model that excludes the construct of relatedness [33] was retained. This model suggests that improvements in health behavior can be explained by improvements in three SDT constructs: increased perceived autonomy support, improved self-determined motivation (decreased controlled vs increased autonomous motivations), and increased perceived competence [33,34]. Perceived autonomy support refers to the perception that during an intervention or interaction with a significant other, choices were provided, rationale was offered, and acknowledgement or empathy was expressed [33]. Controlled motivation refers to actual or future behavior change that is imposed by others or that is motivated out of a sense of guilt and shame in the presence of failure in change [33]. Autonomous motivation refers to actual or future behavior change that is volitional, aligned with one’s goals and values, or motivated by sheer enjoyment [33]. Perceived competence, similar to self-efficacy [34], refers to the degree of confidence in one’s capability in achieving a health behavior change goal [33]. From the cardiac literature, barrier self-efficacy refers to degree of confidence in overcoming barriers towards health behavior change [35]. A systematic review found that the relationships between these SDT constructs and physical activity outcomes were well supported [36], suggesting that interventions that are efficacious at influencing positive changes in SDT constructs may also influence improvements in physical activity outcomes.

SDT is a novel approach to theoretical grounding in the Web-based physical activity literature as no studies using SDT were found in past meta-analyses in either general adult populations [17] or ACS patients [22]. However, we found three full-sized RCTs testing the effect of Web- and SDT-based

interventions in general adult populations that were powered on self-reported physical activity outcomes [37,38] or a composite outcome that included physical activity [39]. Among the two RCTs powered on a self-reported physical activity outcome, the most recent found a significant increase of 71 minutes in weekly moderate to vigorous physical activity at 12 months in favor of the SDT-based intervention compared with a waitlist control [37]. In this RCT, the SDT-based intervention consisted of tailored messages delivered in text format and nontailored information (motivational and educational) delivered by videos of a physical activity expert. In the other RCT, the authors did not report effects on physical activity outcomes in their conference abstract [38]. In the RCT powered on a composite outcome of self-reported weight, diet, smoking, and physical activity, the authors reported no effect on the physical activity outcome, which was possibly due to a lack of intervention utilization because too many choices were given in intervention intensities and modes of delivery in the experimental group [39]. Therefore, the Web- and SDT-based intervention literature is sparse [37-39], despite the solid evidence supporting the positive associations between SDT constructs and physical activity outcomes [36]. To our knowledge, no RCT has tested a Web- and SDT-based intervention on physical activity outcomes in ACS patients whether sufficiently active or not. In addition, an innovation not yet examined in the Web-based ACS literature is the use of fully automated videos in tailored interventions. Use of videos could better convey the nurses' strengths-based "way of being" because patients can view and listen to the nurse who presents tailored motivational and educational information instead of reading this same information in text format.

Study Aim and Hypotheses

The aim of this RCT is to evaluate in insufficiently active ACS patients, the effect of a fully automated, Web-based tailored nursing intervention (TAVIE en m@rche) on increased steps per day. Our primary hypothesis is that ACS patients in the experimental group receiving TAVIE en m@rche compared with the control group receiving hyperlinks to publicly available websites will demonstrate a greater increase in change in steps per day between randomization and 12 weeks (H1). Secondary hypotheses are a greater increase in change in steps per day between randomization and 5 weeks (H2), and in energy expenditure for walking and moderate to vigorous physical activity between randomization and 5 weeks, and randomization and 12 weeks (H3 to H6).

We are interested in assessing if the change in SDT variables immediately postintervention at 5 weeks will explain the hypothesized increase in steps per day at 12 weeks. Therefore, we will explore the mediating role of the SDT constructs (perceived autonomy support, controlled and autonomous motivations, perceived competence) and barrier self-efficacy on the effect of TAVIE en m@rche on increased steps per day at 12 weeks (H7 to H11 respectively).

We will also explore the effect of TAVIE en m@rche at 12 weeks on improved quality of life (global, emotional, physical, and social), smoking, medication adherence, secondary prevention program attendance, emergency visits, and hospitalizations (H12 to H20). The potential moderating role of sex on the effect of TAVIE en m@rche on steps per day at 12 weeks will also be explored (H21). Finally, we expect no adverse effect, which is represented by an equal level of angina symptom frequency at 12 weeks in both groups (H22).

Methods

This section is presented according to the SPIRIT 2013 statement in defining standard protocol items for clinical trials [40]. The completed CONSORT EHEALTH checklist [16] is found in Multimedia Appendix 1.

Study Design and Settings

The study design is a two-group parallel multicenter RCT testing the effect of an experimental group that is receiving access to a 4-week Web-based tailored nursing intervention (TAVIE en m@rche) and a brief "booster" at 8 weeks, compared with a control group that is receiving access to hyperlinks of publicly available websites on increased steps per day. Study settings are at four major teaching hospital centers in Montreal, Canada.

Eligibility Criteria

Patients are eligible if they are home the third week after an ACS-related hospitalization, have no serious medical condition that would impede adhering to moderate intensity physical activity, report access in any location to a computer with a USB port that is connected to the Internet, and report the ability to read and speak French. Patients are ineligible if they self-report sufficient physical activity during 6 months prior to the hospitalization where they are recruited (ie, performed at least 150 minutes [30 minutes 5 days a week] of moderate intensity physical activity per week or at least 75 minutes [25 minutes 3 days per week] of vigorous intensity physical activity per week), have documented New York Heart Association Class III-IV heart failure, or reported planned involvement in intensive regular clinical follow-up (eg, an outpatient heart failure clinic) during TAVIE en m@rche. One hospital center asked that those who are eligible for participation in their onsite secondary prevention program (ie, new diagnosis of ACS and age <75 years) be ineligible for study participation to avoid delivery of parallel secondary prevention interventions at that center.

Interventions

Both groups receive usual care from hospital entry to return home. At all four recruitment centers, from hospital entry to hospital discharge, usual care consists of brief counseling by hospital staff on discharge issues such as new medications and their side effects and on health behavior changes such as progressively increasing physical activity at home. Printed materials are provided as teaching aids to complement the brief counseling. As well, patients receive referrals to onsite or community-based secondary prevention programs.

After hospitalization, all centers offer secondary prevention programs, but at varying doses. All offer an educational group program on the topic of cardiac risk factors and health behaviors aimed at reducing these risk factors, but the number of sessions varies between one and eight across the four centers. Also, three of the four centers offer onsite supervised exercise programs,

but the number of sessions vary between one to three times per week. Two of the programs are 12 weeks in duration, and the other lasts 1 year.

Control Group

The control group receives a list of four hyperlinks on a unique webpage of available online information that is Canadian, French, and that included information on walking. Three major Canadian nonprofit or public organizations are included: Montreal Heart Institute, Heart and Stroke Foundation, and Canadian Society for Exercise Physiology. In addition, because key recommendations on walking post ACS-related hospitalization were derived from a patient education booklet published by the Montreal Heart Institute that is available online, the walking program in this booklet is also included in the list of hyperlinks. All websites provide information in text format without the use of videos.

Experimental Group

The experimental group receives access to TAVIE en m@rche. The central feature of TAVIE en m@rche is the prerecorded videos of a nurse (see Multimedia Appendix 2) who presents the fully automated tailored intervention content delivered according to patients' baseline assessments of autonomous motivation, perceived competence, and walking behavior. Other modes of delivery include online text that appears beside the videos to allow simultaneous reading of the video's content, and downloadable PDF files referred to by the nurse. Access to TAVIE en m@rche starts at randomization between the fourth and fifth week after hospitalization, which depends on when the baseline online assessment is submitted. The suggested completion time of the intervention is 4 weeks but access to the intervention ends at 11 weeks postrandomization. An additional brief "booster" is added at 8 weeks postrandomization. We estimate about 60-75 minutes is sufficient to complete the intervention. TAVIE en m@rche consists of 73 videos, each lasting on average nearly 1 minute with most (n=68) lasting less than 2 minutes. The TAVIE platform has simple webpage layouts and is easy to navigate [41].

The intervention goal is to encourage a progressive increase in walking behavior, up to the recommended 150 minutes per week at moderate intensity, which is determined by an adapted version of the Borg Rating of Perceived Exertion [42]. This walking level is recommended to all patients at discharge for an ACS-related hospitalization by their treating physician unless a contraindication is present such as comorbid physical condition or an environmental constraint. Such patients are ineligible for study participation.

The intervention is based on a theoretical framework that integrates SBNC with SDT. SBNC focuses on nursing values such as fostering a collaborative partnership with the person, supporting the person's self-determination in their decisions and actions, and working with the person's strengths in the aim of achieving health and healing. The SDT on human motivation specifies theoretical constructs for physical activity to be targeted by the intervention strategies and to drive the tailoring process. The intervention strategies are specifically targeted toward increasing self-reported perceived autonomy support, autonomous motivation, and/or confidence (combined perceived competence and barrier self-efficacy).

The appeal of using videos as the main mode of delivery, rather than text-only format, is the greater ability to convey the strengths-based nursing way of being that is manifested in part by nonverbal behaviors such as tone of voice (eg, energetic vs neutral) and body language (eg, smiling vs a sincere nonjudgmental expression), and by verbal behaviors (ie, the nurse's script). This script, consistent with both SBNC and SDT, drawn from our past literature review [43], followed five global strategies: being collaborative, being strengths-focused, providing choice, offering rationale, and expressing empathy. These global strategies can be thought of as the fabric in which the entire intervention content is interwoven. As such, we expect that the use of videos instead of text-only format will be more interesting and motivating to participants because the SBNC way of being will be better conveyed.

The intervention consists of four specific strategies targeting increasing perceived autonomy support, autonomous motivation, and/or confidence aimed at increasing walking behavior: Strategy (1) Providing information and feedback to build motivation and confidence; Strategy (2) Exploring reasons to build motivation; Strategy (3) Exploring personal strengths to build confidence; and Strategy (4) Developing an action plan to build and consolidate motivation and confidence. These strategies are operationalized by 19 behavior change techniques. The terminologies of those 19 techniques were made consistent with those of the CALO-RE taxonomy [44] (Table 1). These behavior change techniques were drawn from three main literary sources: (1) SDT-based physical activity face-to-face or Web-based interventions and Motivational Interviewing due to its consistency with SDT [45], (2) facilitators of physical activity such as improved cardiac health and quality of life, and barriers of physical activity such as lack of time and the presence of fatigue and depressive symptoms found in cardiac patients, and (3) two patient education booklets on the secondary prevention of ACS [42,46]. The content validity of comparing intervention strategies (global and specific) with the theoretical background was done by the Université de Montréal scientific PhD jury of the first author. One cardiac nurse reviewed the operationalization of the entire intervention, and two clinical kinesiologists in secondary prevention reviewed the operationalized information on walking.

Table 1. Specific strategies, intermediate intervention goals, behavior change techniques, and targeted SDT variables.

Specific strategy	Intermediate intervention goal	Behavior change technique	Targeted SDT variable[a]
1. Providing information and feedback on walking behavior	To help patients build or consolidate motivation and confidence to increase walking behavior or maintain sufficient walking behavior	1.1 Provide information on consequences of behavior in general by providing information on potential advantages of physical activity through walking	Perceived autonomy support from the intervention Autonomous motivation
		1.2 Provide instruction on how to perform the behavior of attaining the recommended minutes per week of physical activity through walking	Perceived autonomy support from the intervention Confidence
		1.3 Provide feedback on performance tailored to minutes per week of walking in the past 7 days	Perceived autonomy support from the intervention Confidence
2. Exploring reasons to increase walking behavior	To help patients build motivation to increase walking behavior	2.1 Motivational interviewing, asking evocative questions to explore advantages of increasing walking behavior, and to explore goals and values[c]	Perceived autonomy support from the intervention Autonomous motivation
		2.2 Motivational interviewing, sharing a list of potential reasons to increase walking behavior[c]	Perceived autonomy support from the intervention Autonomous motivation
3. Exploring strengths	To help patients build confidence to increase walking behavior	3.1 Motivational interviewing, asking evocative questions to explore strengths[c]	Perceived autonomy support from the intervention Confidence
		3.2 Motivational interviewing, sharing a list of potential strengths[c]	Perceived autonomy support from the intervention Confidence

Specific strategy	Intermediate intervention goal	Behavior change technique	Targeted SDT variable[a]
4. Developing an action plan	To help patients consolidate their motivation and confidence to increase walking behavior or maintain sufficient walking behavior	4.1 Provide instruction on how to perform the behavior of perceived exercise exertion assessment and planning walking in four steps	Perceived autonomy support from the intervention Confidence
		4.2 Teach to use prompts/cues using flash card of perceived exertion and the four steps	Perceived autonomy support from the intervention Confidence
		4.3 Goal setting using SMART goals	Perceived autonomy support from the intervention Confidence
		4.4 Provide information on consequences of behavior in general by providing information on potential advantages of walking, and how to make walking enjoyable	Perceived autonomy support from the intervention Autonomous motivation
		4.5 Teach to use prompts/cues using flash card of SMART goals and reasons for walking	Perceived autonomy support from the intervention Autonomous motivation Confidence
		4.6 Prompt self-monitoring of behavior of SMART goals	Perceived autonomy support from the intervention Autonomous motivation[b] Confidence
		4.7 Provide information on where and when, and instruction on how to perform the behavior using practical tips to increase walking behavior or to maintain sufficient walking behavior	Perceived autonomy support from the intervention Confidence
		4.8 Prompt review of the identification of behavioral goals (SMART goals, and reasons for walking)	Perceived autonomy support from the intervention Autonomous motivation Confidence
		4.9 Barrier identification/problem solving	Perceived autonomy support from the intervention Autonomous motivation[b] Confidence
		4.10 Plan social support to elicit support from significant others in the attainment of increasing walking behavior or maintaining sufficient walking behavior	Perceived autonomy support from the intervention Perceived autonomy support from a significant other
		4.11 Provide an example of action planning	Perceived autonomy support from the intervention Autonomous motivation[b] Confidence
		4.12 Provide feedback on performance (action plan and walking behavior)	Perceived autonomy support from the intervention Confidence

[a]Perceived autonomy support from the intervention is targeted throughout because the global strategies (Being Collaborative, Being Strengths-Focused, Providing Choices, Offering Rationale, and Expressing Empathy), which are consistent with both SBNC and SDT, are integrated within each specific strategy.

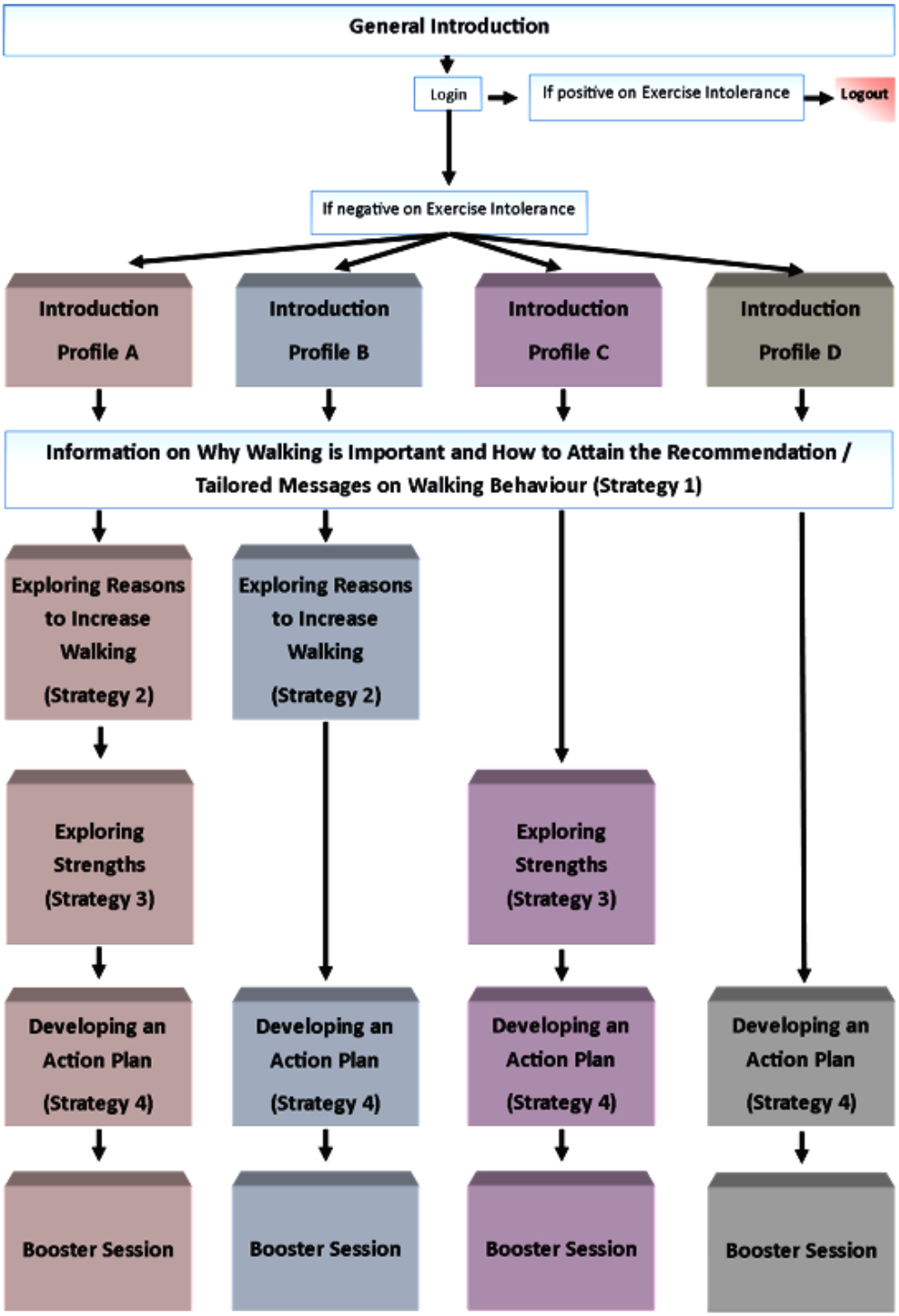
[b]Autonomous motivation targeted 4.6 in the enjoyment in monitoring the accomplishments of a SMART goal; 4.9 in two barriers: (1) not having enough time to walk, and (2) having no reason to walk; and 4.11 in the example of reasons for increasing walking behavior within an action plan.

[C]Motivational Interviewing is reported here as behavior change techniques consistent with the CALO-RE taxonomy and is limited to open-ended questions consistent with Motivational Interviewing, without the back-and-forth aspect of face-to-face counseling found in an interview.

The strategies are conveyed through a set of videos that build toward participants' commitment to developing their own action plan. The order of the strategies is determined by the primary static tailoring method that is driven by participants' baseline self-reported autonomous motivation (low vs high), confidence (low vs high), and walking behavior, which resulted in four tailored profiles: A, B, C, and D (Figure 1). Profiles A, B, and C are assigned from scores that are below the recommended 150 minutes per week of walking. Profile A receives Strategies 1 (information), 2 (reasons), 3 (strengths), and 4 (action plan) because this profile is low in motivation and confidence. Profile B receives Strategies 1 (information), 2 (reasons), and 4 (action plan) because this profile is low in motivation. Profile C receives Strategies 1 (information), 3 (strengths), and 4 (action plan) because this profile is low in confidence. Profile D receives Strategies 1 (information), and 4 (action plan) because this profile is high in motivation and confidence. In addition, participants who attained the recommended minutes per week of walking between hospital discharge and baseline receive Profile D.

Secondary methods are the use of tailored messages based on "yes" versus "no" responses to questions after intervention login on identifying symptoms of exercise intolerance in the past 7 days (Introduction). Participants who respond "yes" to having identified symptoms of exercise intolerance are provided an onscreen video message asking them to not initiate the intervention, to consult a free 24-hour province-wide phone service for general health problems if the symptoms are nonurgent, or to call 9-1-1 or go to the emergency department if the symptoms are urgent, and then to log out of the intervention. Two weeks later, participants are asked to log in to the intervention, and only if no symptoms of exercise intolerance are identified by the participant, they are invited to continue the intervention. Static tailored messages on walking behavior (ie, feedback on performance) are also provided to participants in all four profiles (Strategy 1 information) based on their responses of walking behavior assessed only at baseline. Other tailored messages based on "yes" versus "no" responses to questions after intervention login pertain to the identification of personal reasons for walking (Strategy 2 reasons), personal strengths (Strategy 3 strengths), personal goals that are SMART (Specific, Measurable, Attainable, Realistic, and within a Timeframe) (Strategy 4 action plan), social support, and solutions to barriers (Strategy 4 action plan).

Figure 1. Schema of the intervention's general and per profile introductions, and the four specific intervention strategies.



Timeline and Procedures

The study duration is 16-17 weeks, from hospitalization (-T2) to the last assessment at 12 weeks postrandomization (T3). We estimate that 4 hours in the experimental group and 2.5 hours in the control group are needed to participate in the study, which includes time spent in either experimental or control interventions, and the completion of the questionnaires (Table 2).

Table 2. Schedule of enrollment, interventions, and assessments.

		Minutes per patient	Recruitment	Baseline	Randomization	Interventions	Follow-up 5 wks	Follow-up 12 wks
Activity	Items		-T2	-T1	T0	T1	T2	T3
Eligibility screening								
Patient lists		N/A	x					
Inclusion/exclusion interview		~10	x					
Screening log		N/A	x					
Consent and signing		~30	x					
Instruction to wear accelerometer and complete questionnaires		~10		x				
Randomization and allocation to group		~1			x			
Access to experimental or control group interventions		~60-75				x		
Documentation		N/A	x	x	x	x	x	x
Assessments in-hospital								
Sociodemographic data and depression questionnaire	19	~15	x					
Give and explain accelerometer wear		~10	x					
Clinical data (eg, history, tests, events, and cardiac risk factors)		N/A	x					
Assessments at home								
Intervention adherence		N/A				x		
Primary outcome (X) steps/day		N/A		X			x	X
Questionnaires		~30-45						
Self-reported physical activity and location of accelerometer wear	7			x			x	x
Perceived autonomy support of significant other	6						x	
Perceived autonomy support of websites	6						x	
Autonomous and controlled motivations	12			x			x	
Perceived competence	4			x			x	
Barrier self-efficacy	8			x			x	
Quality of life	27			x				x
Smoking status	1			x				x
Medication adherence	4			x				x
Secondary prevention program enrollment	2							x
Angina frequency	2			x				x
Fatigue	7			x				
Clinical data								
Emergency visits and hospitalizations		N/A						x

Recruitment (-T2) takes place in-hospital. Potential participants are identified through patient lists during hospitalization, and we then proceed with preliminary eligibility screening using patients' medical charts (Figure 2). Eligibility screening, rather than being based on a 24-hour and 7-day a week schedule, is based on the recruiters' irregular schedules, which vary depending on their availability to present at one of the four sites or on other constraints such as work (academic or other)

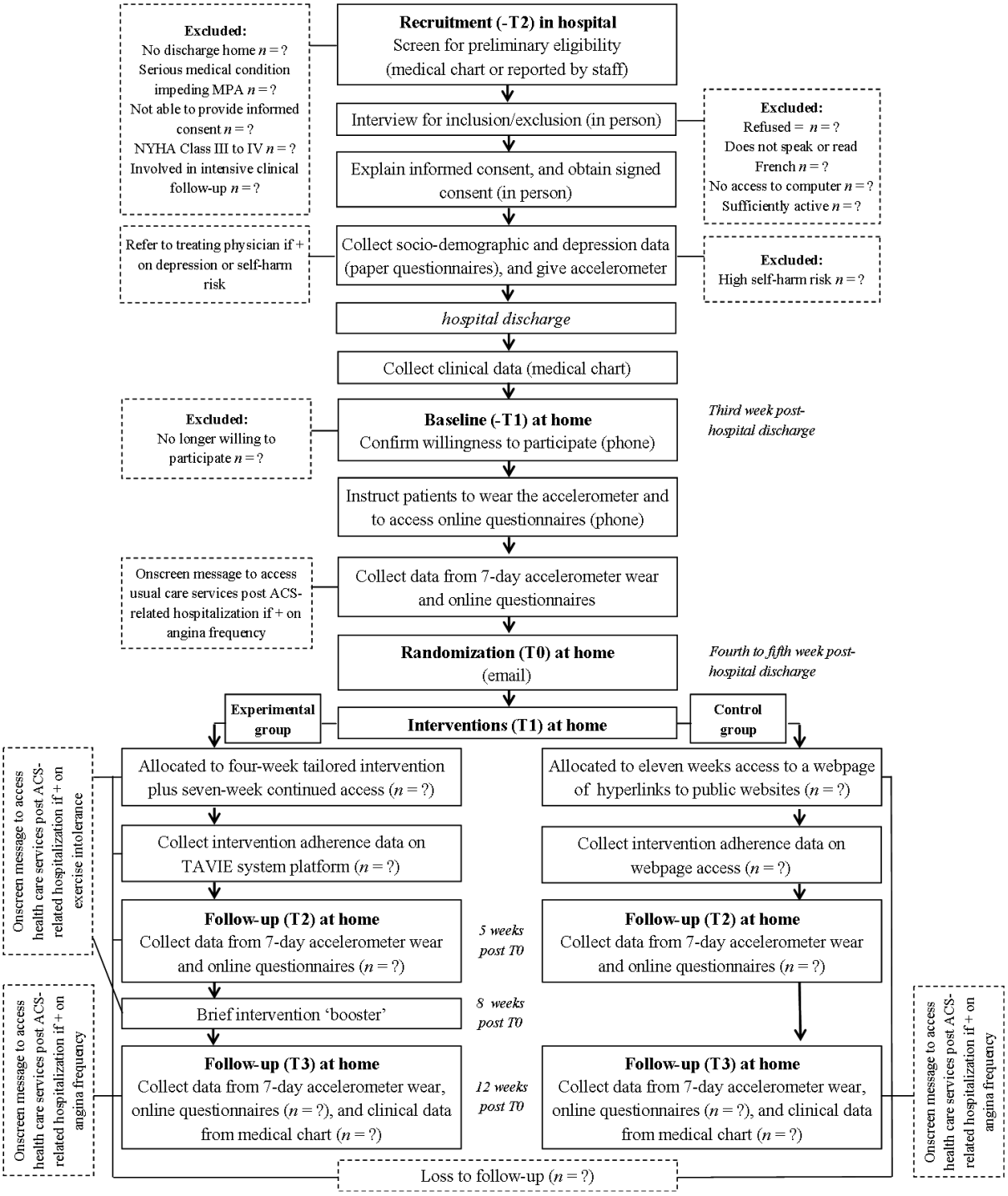
unrelated to recruiting. When potential participants are approached in hospital, eligibility is confirmed (ie, inclusion/exclusion based on in-person interview), and the study protocol is explained. After signed consent is obtained, self-administered paper questionnaires on sociodemographic data and depressive symptoms are completed. Participants are then given an accelerometer and an open prepaid envelope to use when sending it back to the researcher at the end of the study. After hospital discharge, clinical data are collected from the medical chart.

Baseline (-T1) is at the beginning of the third week posthospital discharge. In conjunction with an email, participants are contacted by phone to confirm their willingness to participate. This email includes a hyperlink to download and install the software into the participants' computers, allowing the accelerometer data to be synced to the company's server. Thereafter, the data can then be downloaded into the researcher's computer. During the same phone call, participants are instructed to wear the accelerometer daily for 7 days from awakening to bedtime. After 7 days of accelerometer wear, a second email is sent that includes a hyperlink to access the first online questionnaire. Although we expect most participants to complete the baseline accelerometer wear followed by the online questionnaire within 1 week, a maximum window of 2 weeks is allowed to complete baseline assessments.

Randomization (T0) and allocation to the experimental or control groups occur upon submission of the baseline questionnaire at the fourth or fifth week posthospital discharge, allowing participants the window of 2 weeks to complete baseline assessments. Each participant receives, by automated email from the TAVIE platform, access to either TAVIE en m@rche or the control group involving publicly available websites.

Interventions (T1) start immediately after allocation to the experimental or control groups. Follow-ups at 5 weeks (T2) and 12 weeks (T3) postrandomization are planned. At both follow-ups, participants in both groups (experimental and control) are sent an email with instructions to wear the accelerometer for 7 days. If participants accept, a brief text message is sent to remind them to read the email. After 7 days of accelerometer wear, a second email is sent to complete the online questionnaires. In addition, at the end of data collection, participants are instructed to return the accelerometer by mail via the prepaid envelope provided. During participation, the first author is available by phone and email to resolve technical difficulties in accessing the intervention or questionnaires.

Figure 2. Flow of participants.



Sample Size Calculation

To detect a difference in change between randomization and 12 weeks of 1500 steps per day (SD 2824) in favor of the experimental group compared with the control group, a total of 148 participants (n=74 participants per group [57 plus 17 for attrition], and n=37 per recruitment center) is needed, given a two-sided 5% significance level, power of 80%, and an expected attrition of 23%. The 1500 steps per day is an approximation of half of the recommended daily minutes of moderate intensity physical activity [47]. The attrition of 23% was reported in a meta-analysis of Web-based interventions, in which the experimental groups had an average intervention duration of 13 weeks [17]. The SD of 2824 steps per day was estimated using data found in an RCT of a counseling intervention in ACS patients in Quebec [48].

Randomization and Allocation

Randomization is planned by an offsite coordinating center. It is stratified by study center to help protect against between group imbalances if recruitment differs in one or more study centers [49]. Per stratum, random numbers are given for each

assignment. Random assignments follow a 1:1 allocation using random block sizes determined by the coordinating center to minimize the chance of group imbalances [49].

The assignment sent by the coordinating center in electronic list (.xls) format was uploaded in the TAVIE platform. The allocation sequence is concealed. Upon submission of the baseline questionnaire, the TAVIE platform sends an automated email of the assignment to the participant. This email includes the hyperlink and password to access the experimental TAVIE en m@rche or to receive a different hyperlink to access the control of publicly available websites.

Blinding

Care providers during hospitalization (treating physicians, nurses, and others) are blinded to group assignment because randomization occurs posthospitalization. The first author must know of the assignment after it is revealed, in order to manage the emails sent to participants in either the experimental or control group. The outcome data completed online are anonymized allowing blinding to group assignment. Participants are not blinded to group assignment because they consent to randomly receiving one of two website hyperlinks. Although participants are not informed as to which website is experimental versus control, they are informed that one website takes about 60-75 minutes to complete (ie, experimental), and the other website takes an undetermined number of minutes to complete (ie, control).

Outcomes

Primary Outcome of Steps per Day

The primary outcome is change in steps per day measured by an accelerometer between randomization and 12 weeks. We chose 12 weeks as the primary endpoint rather than 5 weeks to assess the persistence of steps performed beyond the end of the intervention's 4-week period. The accelerometer step count data are concealed, uploaded wirelessly to a server [50], and downloaded in the first author's computer. Similar to step counts measured by a previously validated pedometer, step counts measured by the accelerometer worn on a shoe had less than 2% error compared with observed step counts measured by hand tally counter [50]. Participants are instructed to clip the accelerometer on one of their shoes during waking hours. If they are not wearing shoes, they are then instructed to clip it at their waistline clothing (belt or pants) as recommended by the manufacturer.

The steps per day mean will be estimated using ≥3 valid step-days within the 7-day wear period, which is an accepted norm in adult populations [51]. A valid step-day will be determined by a wear time of ≥10 hours per day [51]. Fewer than 3 valid step-days will be treated as missing data.

Secondary Outcomes of Steps per Day and Energy Expenditure

Secondary outcomes are change in steps per day measured by an accelerometer between randomization and 5 weeks, and in self-reported energy expenditure for walking, and for moderate to vigorous physical activity measured by the French short version International Physical Activity Questionnaire (IPAQ) [52] between randomization, and 5 and 12 weeks. For self-reported energy expenditure, we retained six of the seven items that provided a single continuous score of Metabolic Equivalent of Task (METs)-minutes per week in the last 7 days. The score of energy expenditure for walking is the product of days performed in walking, minutes performed per day, and 3.3 METs. The score of energy expenditure for moderate to vigorous physical activity is the sum of two products: the product of days performed in moderate intensity physical activity (eg, carrying light loads or bicycling at a regular pace), minutes performed per day, and 4.0 METs; and the product of days performed in vigorous intensity physical activity (eg, heavy lifting, or fast bicycling), minutes performed per day, and 8.0 METs. International studies found that the reliability (test-retest) and criterion validity (self-report vs accelerometer data) of the IPAQ generally score around .80 (reliability) and .30 (criterion validity), which is comparable with psychometrics of other self-report physical activity questionnaires [53].

Outcomes of Theoretical Variables

Two outcomes assessed only at 5 weeks for Perceived autonomy support (PAS) were drawn from a French version of the Important Other Climate Questionnaire: (1) from a significant other (PAS-SO) and (2) from the intervention (PAS-WEB). These measures assess autonomy support felt from a significant other (PAS-SO) and from either research website visited (PAS-WEB). The two scores are the mean of responses of 6 items for each PAS (significant other [SO] vs intervention [WEB]) rated between "not at all true" (1) and "very true" (7). Higher scores represent greater levels of PAS. Reported Cronbach alphas across three assessments were between .86 and .89 [54].

Self-determined motivation is assessed at baseline and 5 weeks by the French version of the Treatment Self-Regulation Questionnaire. This measure assesses reasons to attain the recommendation of walking 150 minutes per week. We retained the 12 items that assess controlled motivation (6 items) and autonomous motivation (6 items). The two scores are the mean of responses of 6 items for each motivation (controlled vs autonomous) rated between "not at all true" (1) and "very true" (7). Higher scores represent greater levels of controlled and autonomous motivation. Reported Cronbach alphas across four populations were between .73 and .91 for controlled motivation, and between .85 and .93 for autonomous motivation [55].

Perceived competence is assessed at baseline and 5 weeks by the French version Perceived Competence Scale [53]. This measure assesses confidence to attain the recommendation of walking 150 minutes per week. The score is the mean of responses of 4 items rated between "not true at all" (1) and "very true" (7). Higher scores represent greater levels of perceived competence. Reported Cronbach alphas across two assessments were .93 and .96 [54].

Barrier self-efficacy is assessed at baseline and 5 weeks by the French version Barrier Self-Efficacy Scale for cardiac patients [35]. This measure assesses confidence to walk for the recommended 150 minutes per week even if one or more of eight barriers listed are experienced. We retained 8 of the 9 items. The item removed referred to the barrier of experiencing

angina or chest pain. Instead of overcoming this barrier, we expect that participants treat the pain and consult a health care professional if the pain is not relieved instead of continuing to increase their walking behavior. The score is the mean of responses of 8 items rated between "(0%) not at all confident" and "(100%) very confident." Higher scores represent greater levels of barrier self-efficacy. A reported Cronbach alpha was .86 in the original 9-item scale [35].

Clinical Outcomes

Quality of life is assessed at baseline and 12 weeks by the French version MacNew Heart Disease Health-related Quality of Life Questionnaire for cardiac patients [28]. The 27 items assess, in the previous 2 weeks, global quality of life and its 3 subdimensions: emotional (14 items), physical (13 items), and social (13 items) [56]. Items include reverse scores and overlap across dimensions. The scores for global quality of life and each dimension are the mean of responses that range between 1 (poor quality of life), and 7 (high quality of life). Reported Cronbach alphas were .94, .94, .89, and .90 in global, emotional, physical, and social respectively [57].

Self-reported 7-day point prevalence smoking status, an accepted norm in assessing smoking status outcomes [58], is assessed at baseline and 12 weeks. The following question is used: "Have you smoked a cigarette, even a puff, in the past 7 days?" (p. 4 [59]), answered with "yes" (0), "no" (1), or "never smoked" (2). Point prevalence assessment had a sensitivity of 96.9% and specificity of 93.4% in detecting dichotomous smoking versus nonsmoking status compared with urinary cotinine [60].

Medication adherence is assessed at baseline and 12 weeks by the Self-Reported Morisky Medication Adherence Scale (MMAS-4) [61]. This measure assesses barriers to cardiac medication use in the previous 2 weeks such as forgetting to take them and stopping them because one feels well. The score is the sum of 4 items rated "no" (0) or "yes" (1) such that lower scores indicate better medication adherence. Scores are dichotomized between medium to low (1 to 4) and high (0). The MMAS-4 had a sensitivity and specificity of 81.0% and 44.0% respectively in predicting controlled blood pressure [61].

Secondary prevention program attendance is measured at 12 weeks by self-report rated by "no" (0) or "yes" (1) of at least one visit, since hospitalization, to a secondary prevention program that offers clinical follow-up with a health care professional for general health, medication adherence, healthy diet, smoking cessation, or exercise. No data on baseline attendance are collected because programs may start 4 weeks or later posthospitalization, which falls around the planned time of randomization.

Data for both emergency department visits and hospitalizations are collected from the medical records at 12 weeks at each study center. For each outcome, one or more emergency department visits or hospitalizations for any reason indicate a score of 1 and no emergency department visits or hospitalizations indicate a score of 0.

Angina frequency is assessed at baseline and 12 weeks by the angina frequency scale of the Seattle Angina Questionnaire. This measure assesses frequency of angina pain and nitroglycerin use that we changed from "in the past 4 weeks" to "in the past 2 weeks." The score is the sum of responses of 2 items rated between "4 or more times per day" (1) and "none over the past 2 weeks" (6), which is then transformed to score between 0 (worst) and 100 (best). Lower scores represent greater angina frequency. A reported significant positive association was r=.31 between greater angina frequency and greater number of refills of sublingual nitroglycerin tablets in the previous year [62].

Sociodemographic and Clinical Data

At recruitment in hospital (-T2), sociodemographic and clinical data are collected. Nine items in a paper-based self-report questionnaire assess employment, education, marital status, and other demographics. Other data including medical history, diagnosis, laboratory tests, in-hospital events, cardiac risk factors, intermittent claudication, and documented referral to a secondary prevention program are collected from the medical chart after hospitalization. Also, depressive symptoms are assessed at recruitment (-T2) by the 9-item French version Patient Health Questionnaire (PHQ-9). The PHQ-9 administered at recruitment in hospital allowed us to refer participants with abnormal scores to the treating cardiologist. At baseline (-T1), fatigue is measured by the 7-item short form French version [63]. Based on our literature review prior to commencing our RCT, depression and fatigue were retained as potential covariates rather than outcome variables because of the uncertainty that Web-based interventions in ACS populations can decrease depression symptoms [28] and because it is unknown if such interventions can decrease fatigue as this variable has not been previously tested in the Web-based ACS literature.

Intervention Adherence

During the intervention (T1), intervention adherence data are collected. For TAVIE en m@rche, data are collected on the number of times videos and webpages are viewed and documents are downloaded. Time spent in the intervention will be estimated from these data. For the control group website, data on the number of website visits per person are collected by Google Analytics. Because the control group is provided a single webpage of hyperlinks of publicly available websites, collecting data from these websites is not possible.

Statistical Methods

The Montreal Health Innovations Coordinating Center provided expertise for the statistical methods. Baseline characteristics will be compared using descriptive statistics to identify trends in group imbalances, and the analyses will be consistent with intention-to-treat principles, in which data at a given time point will not be excluded from the analysis [64]. Missing data will be examined and handled according to best practice in that field [65].

For the analyses of single continuous variables (eg, the primary outcome of change in steps per day), repeated measures analysis of covariance models will be used with covariates that include gender, age, diabetes, intermittent claudication, baseline smoking status, depression symptoms, and fatigue. For analyses of multiple continuous variables (eg, the secondary outcomes

of change in walking and moderate to vigorous physical activity), repeated measures multivariate analysis of covariance models will be used with the same covariates as the above model. For single dichotomous variables with baseline values (eg, smoking status), sequential logistic regression models will be used. For single dichotomous variables without baseline values (eg, hospitalizations), chi-square models will be used. A mediation analysis will use a sequence of one-way analysis of variance models with Bonferroni adjustments, in which the alpha will be divided by the number of tests performed. Adjusted and unadjusted means or proportions in each group (experimental and control) will be provided along with a 95% confidence interval. No adjustments in *P* values will be made for the hypotheses on secondary and tertiary outcomes because these are aimed at supporting the primary hypothesis on steps per day rather than claiming intervention effect [66].

Ethical Considerations

Ethics approval for this multicenter RCT was obtained from the Scientific and Ethics Committee of the Montreal Heart Institute Research Center (reference #MP-33-2015-1887). Procedures follow the mechanism of multicenter studies outlined by the Quebec Ministry of Health and Social Services [67].

We expect that the study population has no additional adverse effects in participating in this RCT because the recommendation for physical activity (ie, walking 150 minutes per week) is consistent with current cardiology practice. Also, past research found that cardiac patients can safely participate in physical activity at home [68,69]. As such, we hypothesize that angina frequency will be equivalent in both groups (experimental vs control).

Results

This RCT is currently recruiting. Recruitment started March 30, 2016, and data analysis is planned for November 2017.

Discussion

Limitations

We aim to test in insufficiently active ACS patients, the effect of receiving a Web-based tailored nursing intervention (TAVIE en m@rche) on increasing steps per day compared with receiving hyperlinks to publicly available websites. There exist potential limitations in our RCT pertaining to outcomes, intervention, and generalizability.

Outcomes

First, although our primary outcome of steps per day was retained based on the literature showing the association between increased physical activity and reduced mortality in ACS patients [5-7], we did not plan mortality as primary or secondary outcomes. Trials that aim to improve physical activity outcomes usually establish eligibility criteria to select populations that are capable of attaining the amount of physical activity recommended in the intervention. As such, these populations have few comorbidities resulting in low serious adverse cardiac events or mortality. Two RCTs testing Web-based interventions in ACS patients measured an objective physical activity outcome (steps per day or exercise capacity) and reported serious adverse cardiac or mortality events requiring hospitalization per treatment group [28,29]. Reid et al. reported four hospitalisations for chest pain and no deaths in the experimental group, and six hospitalisations for chest pain, one for cardiac surgery and two deaths in the control group during 12 months of follow-up [28] Lear et al. reported three (9%) major cardiac events (e.g., revascularisation, stroke, and death) in the experimental group, and six (16%) in the control group during 16 months of follow-up [29]. These data suggest that fewer serious adverse cardiac or mortality events are found in favor of Web-based experimental groups, and too few events occur to plan mortality as a primary or secondary outcome within a feasible timeframe.

Second, for our secondary outcome of energy expenditure, we plan estimates from self-reported data instead of from accelerometer data. Accelerometers require the entry of participants' weight in the devices to produce the estimates. However, we do not collect data on weight from participants at home before randomization (baseline [-T1]) because these data may be missing or unreliable from self-report or from participants' own weighing scales.

Third, we planned a relatively short follow-up of 12 weeks for feasibility reasons as this RCT is part of a doctoral degree. A longer follow-up on steps per day and other health behavior changes in a future RCT testing TAVIE en m@rche could improve clinical relevance.

Fourth, it is possible that accelerometers are worn by or data from online questionnaires are entered by someone other than the study participant because the outcome data are completed by participants at home. Although we will treat this possibility when examining the outliers, which could reveal some data clearly out of range entered by a different respondent, there are no other provisions made for this limitation.

Fifth, there is a possibility of missing outcome data. Different scenarios for handling missing data will be followed according to best practice in that field [65] by a statistician who is part of an internationally recognized clinical trial reference center (Montreal Health Innovations Coordinating Center). The method of handling missing data will be reported in a future publication of the results.

Interventions

The platform is limited to using static tailoring rather than dynamic tailoring [20]. However, a recent meta-analysis found that dynamic tailoring has not improved effects on health behavior change outcomes compared with static tailoring [21].

Generalizability

Our sample will likely have similar characteristics as the four other RCTs testing a Web-based intervention using steps per day or another objective physical activity outcome in an ACS population [27-30]. Such populations have no important comorbidities or environmental constraints that would impede performance in moderate-intensity physical activity. ACS populations with important comorbidities are neither eligible to participate in our study nor eligible to receive the recommendation to gradually attain moderate intensity walking

beginning the fourth or fifth week after hospitalization, as is recommended in TAVIE en m@rche. Therefore, the eligibility criteria for our RCT is comparable to the ACS population intended for TAVIE en m@rche. Another related cardiac population that could benefit from TAVIE en m@rche, after some minor modifications, are those with stable coronary artery disease, such as stable angina patients requiring elective percutaneous coronary intervention. However, our future results will not be generalizable in stable coronary artery disease populations.

Conclusion

Alternative interventions aimed at increasing the adoption of health behavior changes in the secondary prevention of ACS are clearly needed. Our proposed intervention fills a gap in the literature because no RCT has tested a Web- and SDT-based tailored intervention using videos of a nurse on an objective physical activity outcome in insufficiently active ACS patients. Study strengths include the retained design, a full-scale RCT, which will confirm with confidence the effect of receiving TAVIE en m@rche on the objective primary outcome of steps per day in ACS patients. Also, the intervention's theoretical framework and its operationalization enhance reproducibility. Finally, the framework allows the examination of theoretical processes, such as the SDT constructs, which may explain the intervention's effects on the primary outcome. If this RCT is successful, and after its implementation as part of usual care, TAVIE en m@rche could help improve the health of ACS patients at large.

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Authors' Contributions

JWK, SC, and JC are the inventors of TAVIE en m@rche. AB and MP contributed to the theoretical integrity of the intervention. MJ, J-FT, M-JS, JD, JGD, J-FT, and M-AM-C contributed to the scientific and ethical aspects of the protocol. DC contributed to the sample size calculation, randomization and allocation, and statistical methods sections of the protocol.

Conflicts of Interest

Granting of licensing options for marketing VIH-TAVIE will follow study completion.

Multimedia Appendix 1

CONSORT-EHEALTH checklist V1.6.2 [16].

[PDF File (Adobe PDF File), 335KB - resprot_v6i4e64_app1.pdf]

Multimedia Appendix 2

Screenshot of an experimental group webpage.

[BMP File, 1MB - resprot_v6i4e64_app2.bmp]

Multimedia Appendix 3

Peer review approval letter of the first author's scientific committee jury of the Université de Montréal (French only).

[PDF File (Adobe PDF File), 1MB - resprot_v6i4e64_app3.pdf]

References

1. Ko DT, Newman AM, Alter DA, Austin PC, Chiu M, Cox JL, Canadian Cardiovascular Outcomes Research Team. Secular trends in acute coronary syndrome hospitalization from 1994 to 2005. Can J Cardiol 2010 Mar;26(3):129-134 [FREE Full text] [Medline: 20352132]
2. Statistics Canada. Mortality, summary list of causes 2009. 2012. URL: http://www.statcan.gc.ca/pub/84f0209x/84f0209x2009000-eng.pdf [accessed 2016-11-27] [WebCite Cache ID 6mKpohsrV]
3. Writing GM, Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, American Heart Association Statistics Committee, Stroke Statistics Subcommittee. Executive Summary: Heart Disease and Stroke Statistics--2016 Update: A Report From the American Heart Association. Circulation 2016 Jan 26;133(4):447-454 [FREE Full text] [doi: 10.1161/CIR.0000000000000366] [Medline: 26811276]
4. World Health Organization. Cardiovascular diseases. 2005. URL: http://www.who.int/cardiovascular_diseases/en/ [accessed 2016-07-11]
5. Janssen I, Jolliffe CJ. Influence of physical activity on mortality in elderly with coronary artery disease. Med Sci Sports Exerc 2006 Mar;38(3):418-427. [doi: 10.1249/01.mss.0000191185.58467.be] [Medline: 16540827]
6. Gerber Y, Myers V, Goldbourt U, Benyamini Y, Scheinowitz M, Drory Y. Long-term trajectory of leisure time physical activity and survival after first myocardial infarction: a population-based cohort study. Eur J Epidemiol 2011 Feb;26(2):109-116. [doi: 10.1007/s10654-010-9523-8] [Medline: 21116840]
7. Apullan FJ, Bourassa MG, Tardif J, Fortier A, Gayda M, Nigam A. Usefulness of self-reported leisure-time physical activity to predict long-term survival in patients with coronary heart disease. Am J Cardiol 2008 Aug 15;102(4):375-379. [doi: 10.1016/j.amjcard.2008.03.072] [Medline: 18678290]
8. Moore SC, Patel AV, Matthews CE, Berrington de Gonzalez A, Park Y, Katki HA, et al. Leisure time physical activity of moderate to vigorous intensity and mortality: a large pooled cohort analysis. PLoS Med 2012;9(11):e1001335 [FREE Full text] [doi: 10.1371/journal.pmed.1001335] [Medline: 23139642]
9. Shepherd CW, While AE. Cardiac rehabilitation and quality of life: a systematic review. Int J Nurs Stud 2012 Jun;49(6):755-771. [doi: 10.1016/j.ijnurstu.2011.11.019] [Medline: 22197653]
10. Stone J, Campbell N, Genest J, Harris S, Pipe A. Canadian Association of Cardiac Rehabilitation. Warburton DER; 2009. Health behaviour interventions and cardiovascular disease risk factor modifications URL: http://www.cacpr.ca/guidelines-login.cfm [accessed 2016-11-27] [WebCite Cache ID 6mKrELGix]
11. Prochaska JJ, Spring B, Nigg CR. Multiple health behavior change research: an introduction and overview. Prev Med 2008 Mar;46(3):181-188 [FREE Full text] [doi: 10.1016/j.ypmed.2008.02.001] [Medline: 18319098]
12. Reid RD, Morrin LI, Pipe AL, Dafoe WA, Higginson LAJ, Wielgosz AT, et al. Determinants of physical activity after hospitalization for coronary artery disease: the Tracking Exercise After Cardiac Hospitalization (TEACH) Study. Eur J Cardiovasc Prev Rehabil 2006 Aug;13(4):529-537. [doi: 10.1097/01.hjr.0000201513.13343.97] [Medline: 16874141]
13. Grace SL, Bennett S, Ardern CI, Clark AM. Cardiac rehabilitation series: Canada. Prog Cardiovasc Dis 2014;56(5):530-535 [FREE Full text] [doi: 10.1016/j.pcad.2013.09.010] [Medline: 24607018]
14. Grace SL, Abbey SE, Shnek ZM, Irvine J, Franche RL, Stewart DE. Cardiac rehabilitation II: referral and participation. Gen Hosp Psychiatry 2002;24(3):127-134. [Medline: 12062136]
15. Karmali KN, Davies P, Taylor F, Beswick A, Martin N, Ebrahim S. Promoting patient uptake and adherence in cardiac rehabilitation. Cochrane Database Syst Rev 2014 Jun 25(6):CD007131. [doi: 10.1002/14651858.CD007131.pub3] [Medline: 24963623]
16. Eysenbach G, CONSORT- E. CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. J Med Internet Res 2011 Dec 31;13(4):e126 [FREE Full text] [doi: 10.2196/jmir.1923] [Medline: 22209829]
17. Davies CA, Spence JC, Vandelanotte C, Caperchione CM, Mummery WK. Meta-analysis of internet-delivered interventions to increase physical activity levels. Int J Behav Nutr Phys Act 2012 Apr 30;9:52 [FREE Full text] [doi: 10.1186/1479-5868-9-52] [Medline: 22546283]
18. Kreuter M. Tailoring health messages: customizing communication with computer technology. Mahwah, NJ: Lawrence Erlbaum Associates; 2013.
19. Lustria MLA, Cortese J, Noar SM, Glueckauf RL. Computer-tailored health interventions delivered over the Web: review and analysis of key components. Patient Educ Couns 2009 Feb;74(2):156-173. [doi: 10.1016/j.pec.2008.08.023] [Medline: 18947966]
20. Krebs P, Prochaska JO, Rossi JS. A meta-analysis of computer-tailored interventions for health behavior change. Prev Med 2010;51(3-4):214-221 [FREE Full text] [doi: 10.1016/j.ypmed.2010.06.004] [Medline: 20558196]
21. Lustria MLA, Noar SM, Cortese J, Van Stee SK, Glueckauf RL, Lee J. A meta-analysis of web-delivered tailored health behavior change interventions. J Health Commun 2013;18(9):1039-1069. [doi: 10.1080/10810730.2013.768727] [Medline: 23750972]
22. Devi R, Singh SJ, Powell J, Fulton EA, Igbinedion E, Rees K. Internet-based interventions for the secondary prevention of coronary heart disease. Cochrane Database Syst Rev 2015 Dec 22(12):CD009386. [doi: 10.1002/14651858.CD009386.pub2] [Medline: 26691216]

23. Zutz A, Ignaszewski A, Bates J, Lear SA. Utilization of the internet to deliver cardiac rehabilitation at a distance: a pilot study. Telemed J E Health 2007 Jun;13(3):323-330. [doi: 10.1089/tmj.2006.0051] [Medline: 17603835]
24. Southard BH, Southard DR, Nuckolls J. Clinical trial of an Internet-based case management system for secondary prevention of heart disease. J Cardiopulm Rehabil 2003;23(5):341-348. [Medline: 14512778]
25. Lindsay S, Bellaby P, Smith S, Baker R. Enabling healthy choices: is ICT the highway to health improvement? Health (London) 2008 Jul;12(3):313-331. [doi: 10.1177/1363459308090051] [Medline: 18579630]
26. Antypas K, Wangberg SC. An Internet- and mobile-based tailored intervention to enhance maintenance of physical activity after cardiac rehabilitation: short-term results of a randomized controlled trial. J Med Internet Res 2014 Mar 11;16(3):e77 [FREE Full text] [doi: 10.2196/jmir.3132] [Medline: 24618349]
27. Devi R, Powell J, Singh S. A web-based program improves physical activity outcomes in a primary care angina population: randomized controlled trial. J Med Internet Res 2014 Sep 12;16(9):e186 [FREE Full text] [doi: 10.2196/jmir.3340] [Medline: 25217464]
28. Reid RD, Morrin LI, Beaton LJ, Papadakis S, Kocourek J, McDonnell L, et al. Randomized trial of an internet-based computer-tailored expert system for physical activity in patients with heart disease. Eur J Prev Cardiol 2012 Dec;19(6):1357-1364. [doi: 10.1177/1741826711422988] [Medline: 21903744]
29. Lear SA, Singer J, Banner-Lukaris D, Horvat D, Park JE, Bates J, et al. Randomized trial of a virtual cardiac rehabilitation program delivered at a distance via the Internet. Circ Cardiovasc Qual Outcomes 2014 Nov;7(6):952-959 [FREE Full text] [doi: 10.1161/CIRCOUTCOMES.114.001230] [Medline: 25271050]
30. Maddison R, Pfaeffli L, Whittaker R, Stewart R, Kerr A, Jiang Y, et al. A mobile phone intervention increases physical activity in people with cardiovascular disease: Results from the HEART randomized controlled trial. Eur J Prev Cardiol 2015 Jun;22(6):701-709. [doi: 10.1177/2047487314535076] [Medline: 24817694]
31. Gottlieb LN. Strengths-Based Nursing Care: Health And Healing For Person And Family. New York: Springer Publishing Company; 2013.
32. Deci E, Ryan RW. Intrinsic motivation and self-determination in human behavior. New York: Plenum; 1985.
33. Ng JY, Ntoumanis N, Thøgersen-Ntoumani C, Deci EL, Ryan RM, Duda JL, et al. Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. Perspect Psychol Sci 2012 Jul;7(4):325-340. [doi: 10.1177/1745691612447309] [Medline: 26168470]
34. Williams GC, McGregor HA, Sharp D, Levesque C, Kouides RW, Ryan RM, et al. Testing a self-determination theory intervention for motivating tobacco cessation: supporting autonomy and competence in a clinical trial. Health Psychol 2006 Jan;25(1):91-101. [doi: 10.1037/0278-6133.25.1.91] [Medline: 16448302]
35. Blanchard CM, Rodgers WM, Courneya KS, Daub B, Knapik G. Does barrier efficacy mediate the gender-exercise adherence relationship during phase II cardiac rehabilitation? Rehabilitation Psychology 2002 Feb;47(1):106-120 [FREE Full text] [doi: 10.1037//0090-5550.47.1.106]
36. Teixeira PJ, Carraça EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: a systematic review. Int J Behav Nutr Phys Act 2012 Jun 22;9:78 [FREE Full text] [doi: 10.1186/1479-5868-9-78] [Medline: 22726453]
37. Friederichs Stijn AH, Oenema A, Bolman C, Lechner L. Long term effects of self-determination theory and motivational interviewing in a web-based physical activity intervention: randomized controlled trial. Int J Behav Nutr Phys Act 2015 Aug 18;12:101 [FREE Full text] [doi: 10.1186/s12966-015-0262-9] [Medline: 26283094]
38. Patrick H, Canevello A, Williams GC. Testing the tenets of self-determination theory in the digital world to promote physical activity. Ann Behav Med 2012;43(1):S143 [FREE Full text]
39. Jacobs N, De Bordeauhuij I, Thijs H, Dendale P, Claes N. Effect of a cardiovascular prevention program on health behavior and BMI in highly educated adults: a randomized controlled trial. Patient Educ Couns 2011 Oct;85(1):122-126. [doi: 10.1016/j.pec.2010.08.024] [Medline: 20888728]
40. Chan A, Tetzlaff JM, Altman DG, Laupacis A, Gøtzsche PC, Krleža-Jerić K, et al. SPIRIT 2013 statement: defining standard protocol items for clinical trials. Ann Intern Med 2013 Feb 05;158(3):200-207 [FREE Full text] [doi: 10.7326/0003-4819-158-3-201302050-00583] [Medline: 23295957]
41. Côté J, Rouleau G, Godin G, Ramirez-Garcìa P, Guéhéneuc YG, Nahas G, et al. Acceptability and feasibility of a virtual intervention to help people living with HIV manage their daily therapies. J Telemed Telecare 2012 Oct;18(7):409-412. [doi: 10.1258/jtt.2012.120218] [Medline: 23034932]
42. Deschênes K, Lacerte M, François P. Santé coeur autonomie.: Institut de cardiologie de Montréal; 2009. URL: https://www.icm-mhi.org/sites/www.icm-mhi.com/files/docs/Doc_aux_patients/Francais/guide_sca_francais.pdf [accessed 2016-11-27] [WebCite Cache ID 6mKurpAWm]
43. Kayser JW, Cossette S, Alderson M. Autonomy-supportive intervention: an evolutionary concept analysis. J Adv Nurs 2014 Jun;70(6):1254-1266. [doi: 10.1111/jan.12292] [Medline: 24279721]
44. Michie S, Ashford S, Sniehotta FF, Dombrowski SU, Bishop A, French DP. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. Psychol Health 2011 Nov;26(11):1479-1498. [doi: 10.1080/08870446.2010.540664] [Medline: 21678185]

45. Markland D, Ryan RM, Tobin VJ, Rollnick S. Motivational Interviewing and Self–Determination Theory. J Soci Clin Psych 2005 Sep;24(6):811-831. [doi: 10.1521/jscp.2005.24.6.811]
46. Patenaude F, Simard M, Vanasse M, Vechuere C. Pour un coeur en santé: Programme de prévention cardiovasculaire. Montreal, Canada: Clinique de prévention cardiovasculaire, Institut de cardiologie de Montréal; 2010.
47. Marshall SJ, Levy SS, Tudor-Locke CE, Kolkhorst FW, Wooten KM, Ji M, et al. Translating physical activity recommendations into a pedometer-based step goal: 3000 steps in 30 minutes. Am J Prev Med 2009 May;36(5):410-415. [doi: 10.1016/j.amepre.2009.01.021] [Medline: 19362695]
48. Houle J, Doyon O, Vadeboncoeur N, Turbide G, Diaz A, Poirier P. Innovative program to increase physical activity following an acute coronary syndrome: randomized controlled trial. Patient Educ Couns 2011 Dec;85(3):e237-e244. [doi: 10.1016/j.pec.2011.03.018] [Medline: 21546203]
49. Friedman L, Furberg C, DeMets D, Reboussin D, Granger C. Fundamentals of Clinical Trials. New York: Springer International Publishing; 2010.
50. Brown DK, Grimwade D, Martinez-Bussion D, Taylor MJD, Gladwell VF. The validity of the ActiPed for physical activity monitoring. Int J Sports Med 2013 May;34(5):431-437. [doi: 10.1055/s-0032-1323723] [Medline: 23184480]
51. Aadland E, Ylvisåker E. Reliability of Objectively Measured Sedentary Time and Physical Activity in Adults. PLoS One 2015;10(7):e0133296 [FREE Full text] [doi: 10.1371/journal.pone.0133296] [Medline: 26192184]
52. The IPAQ group. International physical activity questionnaire: Short last 7 days self-administered format. 2012. URL: http://www.ipaq.ki.se/ [accessed 2012-06-21]
53. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003 Aug;35(8):1381-1395. [doi: 10.1249/01.MSS.0000078924.61453.FB] [Medline: 12900694]
54. Fortier MS, Sweet SN, O'Sullivan TL, Williams GC. A self-determination process model of physical activity adoption in the context of a randomized controlled trial. Psychology of Sport and Exercise 2007 Sep;8(5):741-757. [doi: 10.1016/j.psychsport.2006.10.006]
55. Levesque CS, Williams GC, Elliot D, Pickering MA, Bodenhamer B, Finley PJ. Validating the theoretical structure of the Treatment Self-Regulation Questionnaire (TSRQ) across three different health behaviors. Health Educ Res 2007 Oct;22(5):691-702. [doi: 10.1093/her/cyl148] [Medline: 17138613]
56. Höfer S, Lim L, Guyatt G, Oldridge N. The MacNew Heart Disease health-related quality of life instrument: a summary. Health Qual Life Outcomes 2004 Jan 08;2:3 [FREE Full text] [doi: 10.1186/1477-7525-2-3] [Medline: 14713315]
57. Pavy B, Iliou M, Höfer S, Vergès-Patois B, Corone S, Aeberhard P, et al. Validation of the French version of the MacNew heart disease health-related quality of life questionnaire. Arch Cardiovasc Dis 2015 Feb;108(2):107-117 [FREE Full text] [doi: 10.1016/j.acvd.2014.09.006] [Medline: 25453715]
58. US Department of Health and Human Services. Treating tobacco use and dependence. 2008. URL: http://www.ahrq.gov/professionals/clinicians-providers/guidelines-recommendations/tobacco/clinicians/update/index.html [accessed 2016-07-11]
59. Ossip DJ, Chang Y, Nabi-Burza E, Drehmer J, Finch S, Hipple B, et al. Strict smoke-free home policies among smoking parents in pediatric settings. Acad Pediatr 2013;13(6):517-523 [FREE Full text] [doi: 10.1016/j.acap.2013.06.003] [Medline: 24238677]
60. Noonan D, Jiang Y, Duffy SA. Utility of biochemical verification of tobacco cessation in the Department of Veterans Affairs. Addict Behav 2013 Mar;38(3):1792-1795 [FREE Full text] [doi: 10.1016/j.addbeh.2012.11.006] [Medline: 23261494]
61. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Med Care 1986 Jan;24(1):67-74. [Medline: 3945130]
62. Spertus JA, Winder JA, Dewhurst TA, Deyo RA, Prodzinski J, McDonell M, et al. Development and evaluation of the Seattle Angina Questionnaire: a new functional status measure for coronary artery disease. J Am Coll Cardiol 1995 Feb;25(2):333-341 [FREE Full text] [Medline: 7829785]
63. PROMIS. PROMIS Item Bank v1.0 – Fatigue – Short Form 7a. 2012. URL: http://www.healthmeasures.net/explore-measurement-systems/promis [accessed 2015-05-21] [WebCite Cache ID queryphp]
64. CONSORT. Intention-to-treat analysis. 2013. URL: http://www.consort-statement.org/Contents/Item/Display/500 [accessed 2016-11-27]
65. Graham JW. Missing data analysis: making it work in the real world. Annu Rev Psychol 2009;60:549-576. [doi: 10.1146/annurev.psych.58.110405.085530] [Medline: 18652544]
66. The European Agency for the Evaluation of Medicinal Products. Points to consider on multiplicity issues in clinical trials. 2002. URL: http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2009/09/WC500003640.pdf [accessed 2017-01-28] [WebCite Cache ID 6FjxlOAtN]
67. Gouvernement du Québec. Recherche multicentrique. 2015. URL: http://www.msss.gouv.qc.ca/professionnels/ethique/comites-d-ethique-de-la-recherche/recherche-multicentrique/ [accessed 2016-11-27] [WebCite Cache ID 6mKyAfT8a]
68. Brosseau R, Juneau M, Sirard A, Savard A, Marchand C, Boudreau MH, et al. Safety and feasibility of a self-monitored, home-based phase II exercise program for high risk patients after cardiac surgery. Can J Cardiol 1995 Sep;11(8):675-685. [Medline: 7671177]

69. Miller NH, Haskell WL, Berra K, DeBusk RF. Home versus group exercise training for increasing functional capacity after myocardial infarction. Circulation 1984 Oct;70(4):645-649. [Medline: 6478567]

Abbreviations

ACS: acute coronary syndrome
IPAQ: International Physical Activity Questionnaire
MET: Metabolic Equivalent of Task
MMAS-4: Morisky Medication Adherence Scale
PAS: perceived autonomy support
PAS-SO: perceived autonomy support from a significant other
PAS-WEB: perceived autonomy support from the intervention
PHQ-9: Patient Health Questionnaire
RCT: randomized controlled trial
SBNC: Strengths-Based Nursing Care
SDT: Self-Determination Theory

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Protocol

Rationale and Design of Khuzestan Vitamin D Deficiency Screening Program in Pregnancy: A Stratified Randomized Vitamin D Supplementation Controlled Trial

Maryam Rostami[1*], MSc, PhD; Fahimeh Ramezani Tehrani[2], MD; Masoumeh Simbar[1*], PhD; Farhad Hosseinpanah[3*], MD; Hamid Alavi Majd[4], PhD

[1]Department of Reproductive Health and Midwifery, Faculty of Nursing and Midwifery, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic Of Iran

[2]Reproductive Endocrinology Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic Of Iran

[3]Obesity Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic Of Iran

[4]Department of Biostatistics, Faculty of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic Of Iran

[*]these authors contributed equally

Corresponding Author:
Fahimeh Ramezani Tehrani, MD
Reproductive Endocrinology Research Center
Research Institute for Endocrine Sciences
Shahid Beheshti University of Medical Sciences
Reproductive Endocrinology Research Center
Tehran,
Islamic Republic Of Iran
Phone: 98 21 22439982
Fax: 98 21 22439784
Email: ramezani@endocrine.ac.ir

Abstract

Background: Although there have been marked improvements in our understanding of vitamin D functions in different diseases, gaps on its role during pregnancy remain. Due to the lack of consensus on the most accurate marker of vitamin D deficiency during pregnancy and the optimal level of 25-hydroxyvitamin D, 25(OH)D, for its definition, vitamin D deficiency assessment during pregnancy is a complicated process. Besides, the optimal protocol for treatment of hypovitaminosis D and its effect on maternal and neonatal outcomes are still unclear.

Objective: The aim of our study was to estimate the prevalence of vitamin D deficiency in the first trimester of pregnancy and to compare vitamin D screening strategy with no screening. Also, we intended to compare the effectiveness of various treatment regimens on maternal and neonatal outcomes in Masjed-Soleyman and Shushtar cities of Khuzestan province, Iran.

Methods: This was a two-phase study. First, a population-based cross-sectional study was conducted; recruiting 1600 and 900 first trimester pregnant women from health centers of Masjed-Soleyman and Shushtar, respectively, using stratified multistage cluster sampling with probability proportional to size (PPS) method. Second, to assess the effect of screening strategy on maternal and neonatal outcomes, Masjed-Soleyman participants were assigned to a screening program versus Shushtar participants who became the nonscreening arm. Within the framework of the screening regimen, an 8-arm blind randomized clinical trial was undertaken to compare the effects of various treatment protocols. A total of 800 pregnant women with vitamin D deficiency were selected using simple random sampling from the 1600 individuals of Masjed-Soleyman as interventional groups. Serum concentrations of 25(OH)D were classified as: (1) severe deficient (<10ng/ml), (2) moderate deficient (10-20ng/ml), and (3) normal status (>20ng/ml). Those with severe and moderate deficiency were randomly divided into 4 subgroups and received vitamin D3 based on protocol and were followed until delivery. Data was analyzed according to the intention-to-treat principle.

Results: Recruitment commenced in July, 2014, and as estimated, nearly 3.5 years is needed to complete the study. Results of this study will (1) provide reliable information regarding the prevalence of vitamin D deficiency during pregnancy using universal

vitamin D screening approach and (2) determine the beneficial effects of universal screening and compare the various treatment protocols in terms of pregnancy outcomes.

Conclusions: Since vitamin D deficiency is a prevalent disorder in pregnancy among Iranian population, this study will ensure creation of reliable evidence-based findings and will enable clinicians to better evaluate and treat vitamin D deficient pregnant women.

Trial Registration: International Standard Randomized Controlled Trial Number (ISRCTN): 2014102519660N1; http://www.irct.ir/searchresult.php?keyword=&id=19660&number=1&prt=7805&total=10&m=1 (Archived by WebCite at http://www.webcitation.org/6p3lkqFdV)

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KEYWORDS

vitamin D deficiency; pregnancy; clinical trial

Introduction

The Importance and Function of Vitamin D

Vitamin D as a fat-soluble steroid hormone is mainly synthesized by the skin on exposure to ultraviolet light and to a lesser extent can be ingested in the diet. It undergoes hydroxylation in the liver to produce an inactive supply form of 25-hydroxyvitamin D, 25(OH)D. Circulating 25(OH)D gets converted by renal 1-alpha-hydroxylase to the active form of 1,25-dihydroxyvitamin D3 which is the hormonally active form of vitamin D [1]. Since the half-life of 1,25(OH)D is short, circulating 25(OH)D is considered as the primary indicator of vitamin D status [2].

Vitamin D is best known for its effect on calcium hemostasis and bone metabolism [3], and plays a key role in cell differentiation, apoptosis, antiproliferation, immunosuppression, and antiinflammation in different body systems [4-6]. Recent growing evidence confirms its protective influence on the prevention of certain diseases like cancer [7], cardiovascular disorders [8], falls and fractures [9], autoimmunity [10], type-2 diabetes [11], and depression [12].

Although available data suggest the significant role for vitamin D deficiency in women's reproductive health, the maternal and fetal function of vitamin D during pregnancy is not deeply recognized. One potential role of vitamin D during pregnancy is modulation of immune response [13]; however, evidence shows that it may also have functions on musculoskeletal [14] and cardiovascular systems [15] as well as neural development of the fetus [16]. Moreover, studies report a significant association between maternal vitamin D status and neonatal serum levels [17].

With respect to maternal vitamin D deficiency and adverse pregnancy outcomes, data are inconclusive and need further investigations. Trials have reported lower risk of preeclampsia and gestational diabetes in women receiving vitamin D supplementation compared with no intervention or placebo groups [18,19].

In terms of neonatal outcomes, data suggest reduced risk of preterm birth and low birth weight of less than 2500 grams in women who received vitamin D supplements. Interestingly, several observations have reported the influence of maternal vitamin D status beyond the postnatal period and have found its significant effect on childhood development and growth [20,21]. In regard with other pregnancy outcomes like mode of delivery, infant death, or neonatal biometric parameters, findings are not definite [22].

In recent years, the prevalence of vitamin D deficiency has increased and it is now recognized as a common global health concern and an ongoing pandemic [23]. Moreover, low levels of vitamin D during pregnancy have been reported in many populations worldwide, even in those with abundant sun exposure [24]. Previous findings have reported a varied prevalence of 18 to 84% for hypovitaminosis D during pregnancy, depending on the population studied [25-28]. Its prevalence among certain high-risk groups of pregnant women, particularly those with Middle Eastern origin like Iranian women (with low dietary vitamin D intake, high prevalence of pregestational obesity, and limited sun exposure) has been estimated to be approximately 60-80% [29-31]. However, due to the lack of consensus on the most accurate marker and test of vitamin D deficiency during pregnancy, and the optimal level of 25(OH)D for its definition, vitamin D deficiency assessment during pregnancy is a complicated process [32]. Furthermore, the comparison of vitamin D deficiency among different populations seems relatively troublesome due to the diversity of definitions, heterogeneity of the studied groups, or seasonal variations.

Knowledge Gap

Although advising vitamin D consumption may prevent hypovitaminosis D in pregnant women, at this time there is insufficient evidence to support a recommendation for screening all pregnant women for vitamin D deficiency, and its beneficiary impact on pregnancy outcomes has not been well established. Besides, the optimal required dose during pregnancy is still undefined. In this respect, there is little population-based data available to quantify the treatment of vitamin D deficiency in pregnancy. In addition, the lack of high-quality evidence has hampered the implementation of vitamin D deficiency prevention programs and treatment protocols. Furthermore, there exists scarce data from Iranian population on the prevalence of gestational hypovitaminosis D.

Clinical Endpoints

Primary endpoints are to find out the beneficiary impact of screening of pregnant women for vitamin D deficiency on

pregnancy and neonatal outcomes and assessing the effect of supplementation with vitamin D on these outcomes. In the screening group, within the framework of randomized controlled trial, the endpoint was cord serum concentration of 25(OH)D to compare various doses, regimen, and routes for vitamin D supplementation in pregnancy.

In this regard, primary outcomes are gestational diabetes, preterm delivery, and pregnancy induced hypertension. Secondary outcomes are type of delivery and neonatal outcomes including birth weight (gr); head circumference (cm), height (cm); appearance, pulse, grimace, activity, respiration (APGAR) score 1, 5 minute, icterus, cord falling off time (day), serum calcium concentration (mg/dl), and cord levels of 25(OH)D (ng/ml).

Research Questions

The questions are as follows: (1) How is the status of vitamin D among pregnant women in Khuzestan? (2) Is vitamin D deficiency related to adverse maternal and neonatal outcomes in pregnancy? (3) Does supplementation with vitamin D improve maternal and neonatal outcomes? (4) Is there any difference between various doses, regimen, and route for vitamin D supplementation in terms of pregnancy outcomes? (5) Taken altogether, is it reasonable to advise universal vitamin D deficiency screening program to detect and treat vitamin D deficiency in pregnancy?

Methods

Overall Study Design

This was a 2-phase population-based study. The first phase comprised a population-based cross-sectional study in which 1600 and 900 first trimester pregnant women attending health centers of Masjed-Soleyman and Shushtar, Khuzestan province, Iran were recruited using stratified multistage cluster sampling with probability proportional to size (PPS) method [33]. In the second phase of this study, within the framework of screening regimen, Masjed-Soleyman participants with vitamin D deficiency were assigned to a screening program versus Shushtar participants (as nonscreening arm) to assess the effectiveness of various treatment regimens. Pregnancy outcomes including preterm delivery, miscarriage, preeclampsia, gestational diabetes, and type of delivery and neonatal outcomes including birth weight (gr), head circumference (cm), height (cm), APGAR score 1, 5 minute, icterus, cord falling off time (day), serum calcium (mg/dl) level, and cord concentration of 25(OH)D (ng/ml) were recorded.

Shushtar participants (as nonscreening arm) served as controls and were followed till delivery and any adverse pregnancy outcomes were assessed.

The First Phase

In the first phase, pregnant women attending prenatal care centers of urban areas of Masjed-Soleyman and Shushtar were recruited from July 1-September 31, 2014. Due to the blinding purposes and to avoid contacts among study subjects [34], we chose 2 cities with similar cultural, geographic, nutritional habits, and sun exposure conditions; one of these cities was assigned to intervention.

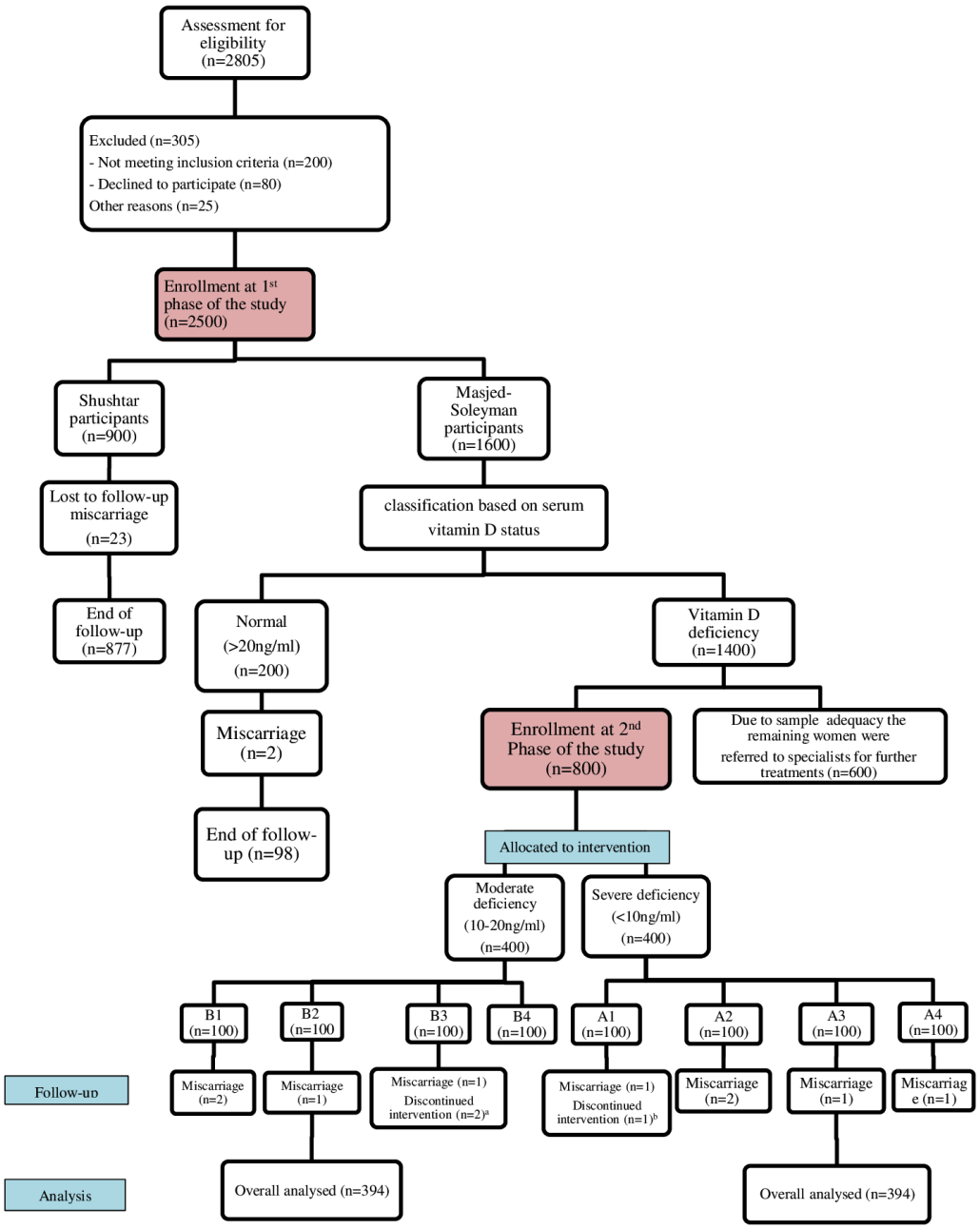
Masjed-Soleyman County is in the northeast of Khuzestan province. Its area is 9/6327 km^2 with a population of 103,369 people with Persian ethnicity. This is a sunny region with a hot and humid climate. Its altitude is 260 meters above sea level. In terms of geographical location, it is between 31°59′ E longitude and 49°17′ N latitude. Shushtar County is in the north of Khuzestan. Its area is 2436 km^2 with a population of 192,361 people with Persian ethnicity. The climate is similar to Masjed-Soleyman. Its altitude is 150 meters above sea level. In terms of geographical location, it is between 48°20′ E longitude and 32°30′ N latitude.

Blood Assessments

Upon enrollment into the study, a fasting blood sample was obtained from all participants. Separated serum samples by centrifugation were transferred to the central laboratory of Masjed-Soleyman (cold chain was kept during storage and transfer processes). The serum samples of participants in Shushtar were stored and kept frozen at -80°C until assayed at the end of the study, but at that time the serum concentration of vitamin D of Masjed-Soleyman participants were promptly measured. Based on 25(OH)D levels, mothers were divided as severe deficient (<10ng/ml), moderate deficient (10-20ng/ml), and normal status (>20ng/ml) [1]. The scale to express 25(OH)D status results was according to ng/ml; each 1 ng/ml is equal to 2.496 nmol/L.

Those participants from Shushtar and those with serum vitamin D>20 ng/ml from Masjed-Soleyman served as controls and were followed until delivery. Subjects with severe and moderate vitamin D deficiency from Masjed-Soleyman were selected for the second phase of the study and were randomly allocated to one of the treatment modalities presented in Figure 1.

Figure 1. The study participant flow diagram. (a) Discontinued intervention due to car accident and humerus injury (n=1) and dislike to continue vitamin D3 supplementation weeks after consumption (n=1). (b) Discontinued intervention due to husband's death and subsequent mental problems.



Subject Recruitment and Eligibility Criteria

Pregnant women, aged 18-40 years, were eligible if they had gestational age <14 weeks based on last menstrual period or obstetrical estimation, singleton pregnancy, and had planned to receive ongoing prenatal and delivery in the Masjed-Soleiman. Participants were excluded if they consumed multivitamins containing more than 400 international unit (IU) per day of vitamin D3; used anticonvulsants; and had history of chronic diseases like diabetes, hypertension, renal dysfunction, liver diseases, and complicated medical or obstetrical history.

Data Collection and Quality Control Procedures

At first, midwives responsible for prenatal care in the selected health centers were invited to attend a workshop designed for explaining the study objectives and procedure. Thereafter, first trimester pregnant women seeking maternity care during their first routine prenatal visit were invited to participate in the study after providing a detailed explanation of the study procedure; they signed a written informed consent during recruitment covering all trial procedures and data collection. For gestational age calculation, the first day of the last menstrual cycle (LMP) for women with regular cycles and ultrasonography for those with irregular cycles or those who could not precisely recall their LMP was used. Pregnant women received prenatal care

and each adverse pregnancy outcome was managed according to the standard guidelines. At enrollment, for each participant a questionnaire that included information on sociodemographic, anthropomorphic, behavioral, and reproductive characteristics was completed by a trained interviewer.

Weight was measured with minimum clothing to the nearest 100 grams. Height was measured with a tape measure in standing position with normal posture of shoulders. Body mass index was calculated by dividing weight (kg) on height (m^2). Systolic and diastolic blood pressures (SBP and DBP) were measured twice in a sitting position with a standard mercury sphygmomanometer after a 15-min rest and the mean of the 2 measurements was considered as SBP or DBP.

A fasting blood sample (5cc) was taken by venipuncture from the antecubital vein. Plasma was then separated by centrifugation (1500g, 10 min, 4˚C) in the central laboratory of Masjed-Soleyman and stored at −20˚C until analysis at the end of the week. Serum concentrations of 25(OH)D for the participants of Masjed-Soleyman were measured immediately, and subsequently their vitamin D status was determined (Table 1). The samples in Shushtar laboratory were stored at −80˚C until the end of the study; finally their serum concentration of vitamin D was measured.

Plasma 25(OH) vitamin D3 was assessed using enzyme-linked immunosorbent assay (ELISA) method and a kit of Immunodiagnostics Systems Ltd (IDS Ltd) by Auto Analyzer (Human Corporation, Germany). The sensitivity of the test was 5nmol/L and the intra and interassay coefficient of variations (CVs) were 3.37% and 3.891%, respectively. Calibration of the instruments was done as per the manufacturer's instructions and validation studies were done prior to the test. All measurements were done according to the standard operating procedures and samples were analyzed by a single technician using the same equipment throughout the study in a reference laboratory.

The Second Phase

In the second phase of the study, to assess the effect of screening strategy on maternal and neonatal outcomes, Masjed-Soleyman participants were assigned to a screening program versus Shushtar participants acting as the nonscreening arm. Within the framework of the screening regimen, an 8-arm blind randomized clinical trial was undertaken to compare the effects of various treatment protocols. Due to the cost and complexity of the process, 800 pregnant women with vitamin D deficiency from Masjed-Soleyman were randomly allocated to 1 of the designed intervention programs according to the study Figure 1. The remaining women with vitamin D deficiency were referred to specialists for further treatments. Participants of Shushtar did not receive any vitamin D supplementation. However, the comparison of the basic confounders between the initial recruited sample in Masjed-Solayman and the women allocated to intervention indicated no statistically significant difference and hence no selection bias occurred during the allocation of treatment (Table 4).

Sample Size Calculation

A cluster sampling method with PPS procedure was assigned. Sample size was calculated in screening group (Masjed-Soleyman) using the following formula (Figure 2) and assumption, resulting in 1537 subjects.

The same steps (except for ε=0.2) were used for calculation of sample size in no screening group (Shushtar), resulting in 900 subjects. Using the cluster sampling method, 1600 and 900 first trimester mothers were selected from among those receiving prenatal care in health centers in urban regions of Masjed-Soleyman and Shushtar, respectively.

Since the prevalence of the specified event is untreated or unrecognized and the number of people who have the risk factor (P) is high in the population, consequently, sample size needed for screening is considered sufficient. In other words, we define a correction coefficient by (1/P) for estimated sample size (n), and then we expect n (1/P) number of people to find the 0.15 difference with 5% significance level.

To compare different regimens used for vitamin D deficiency in the screening group, the sample size in each group was calculated based on the following formula (Figure 3) and assumption:

Considering loss to follow up of 10%, a total number of 100 in each study group was considered adequate.

Figure 2. Sample estimation formula for the first phase of the study.

$$n \geq \frac{z^2_{1-\alpha/2}(1-P)}{\varepsilon^2 P}$$

$$\alpha = 0.05 \Rightarrow z_{1-\alpha/2} = 1.96$$

$$P = 0.10$$

$$\varepsilon = 0.15$$

Figure 3. Sample estimation formula for the second phase of the study.

$$n \geq \frac{\left(z_{\alpha/2} + z_{\beta}\right)^2 \sigma^2 \left(1 + 1/k\right)}{\varepsilon^2}$$

$$\alpha = 0.05 \Rightarrow z_{\alpha} = 1.96$$

$$1 - \beta = 0.90 \Rightarrow z_{\beta} = 1.28$$

$$\varepsilon = \mu_1 - \mu_2$$

$$k = 1$$

$$\theta = effect\ \ size = |\varepsilon| / \sigma = 0.50$$

$$n = 2(1.96 + 1.28)^2 \left(\frac{1}{0.50}\right)^2 = 84$$

Randomization and Blinding

Subjects in each group of severe or moderate deficiencies were randomly divided into 4 subgroups using permuted block randomization by a biostatistician to achieve balance across treatment groups. The number of subjects per block was 8. Sealed opaque envelopes were assigned to each subject by a research assistant not associated in the trial. The dedicated study midwife treating the females, who did not participate in any subsequent phases of the study, was the only person who knew the group each patient belonged to (single blinded). Masking to treatment allocation was not possible and only those health care workers who determined pregnancy outcomes were blinded to treatment allocation.

Intervention

The participants from Masjed-Soleyman entering the second phase of the study received vitamin D as follows.

Women With Severe Vitamin D Deficiency (Group A)

Group A1: Subjects were treated with 50,000 IU of oral vitD3 weekly for a total duration of 12 weeks.

Group A2: Subjects were treated with 50,000 IU of oral vitD3 weekly for a total duration of 12 weeks and then were on monthly maintenance dose of 50,000 IU vitD3 until delivery.

GroupA3: Subjects were treated with intramuscular administration of 300,000 IU vitD3; 2 doses for 6 weeks.

GroupA4: Subjects were treated with Intramuscular administration of 300,000 IU vitD3; 2 doses for 6 weeks and then were on monthly maintenance dose of 50,000 IU vitD3 until delivery.

Women With Moderate Vitamin D Deficiency (Group B)

Group B1: Subjects were treated with 50,000 IU oral vitD3 weekly for a total duration of 6 weeks.

Group B2: Subjects were treated with 50,000 IU oral vitD3 weekly for a total duration of 6 weeks and then were on monthly maintenance dose of 50,000 IU vitD3 until delivery.

GroupB3: Subjects were treated with a single dose of intramuscular administration of 300,000 IU vitD3.

GroupA4: Subjects were treated with a single dose of Intramuscular administration of 300,000 IU vitD3 and then were on monthly maintenance dose of 50,000 IU vitD3 until delivery.

Participants were advised to inform the health care provider about any adverse side effect. A fasting blood sample was obtained 3 months after termination of the intervention for those without maintenance vitamin D therapy (groups A1, A3, B1, and B3) and for all those in other groups at delivery. Also, a cord blood sample was obtained from participants. Separated serum samples after centrifugation were transferred to the central laboratory of Masjed-Soleyman. Samples were stored at −80°C and serum concentrations of vitamin D3 were measured at the end of the study.

Women With Normal Status (Group C)

Subjects in this group and the pregnant women recruited from Shushtar city comprised our controls. They had access to standard prenatal care and were followed until delivery. In the case of any adverse outcome, it was managed according to the perinatal guidelines. Blood sampling from subjects in this group and those from Shushtar was obtained at the first visit. Similar to others groups, another sample was obtained from mothers and umbilical cord at the time of delivery.

Source of Vitamin D

Oral vitamin D3 50 000 U or cholecalciferol tablets were manufactured by Roche Pharmaceutical, Tehran, Iran and dispersed in Iran by Zahravi, Tehran, Iran. Intramuscular D3 injection of 1-ml ampoule, 300 000 IU/ml in sesame oil, was manufactured by Caspian Pharmaceutical, Iran.

Adherence to Medication Regimen

Adherence to the supplementation regimen was measured by maternal self-report and pill counts at each prenatal visit. The number of pills returned was divided by the expected number of pills that would have been taken to create a percentage that indicates the adherence of medication regimen. The measures were used to make an average adherence for each subject [35].

Statistical Analysis

Data will be expressed as mean (standard deviation, SD) for normally distributed variables and frequency (%) or median (interquartile range, IQR) for categorical and or nonnormal variables. Continuous variables are checked for normality using the one sample Kolmogorov-Smirnov test. Distribution of variables between the 2 groups is compared using *t* test or Mann-Whitney nonparametric test in case of normality violation and reported as mean (SD). Categorical variables are compared using Pearson and chi-square tests. An intention-to-treat analysis of the results is used. Generalized linear models will be used to assess the relationships between outcomes and exposures (here vitamin D3 supplementation intervention) adjusted by appropriate covariates. Analyses will be performed using the software SPSS version 19 (SPSS Inc). *P* value of less than .05 is considered as significance level.

Table 1. The steps of study analysis.

Proceedings	Stage
Obtaining written inform consent form and completing the questionnaire	Recruitment and completion of the questionnaire
Determining groups according to their status of vitamin DCollection of the laboratory samples	Classification
Obtaining fasting blood samples. Assessment of serum concentration of vitamin D in Masjed-Solayman immediately and storing Shustar samples at −80°C	
Obtaining fasting blood samples 3 months after termination of the intervention for those without maintenance vitamin D therapy (groups A1, A3, B1, and B3) and for all women at delivery time. Obtaining cord blood sample from all participantsStart of intervention	Replication of laboratory samples
Prescription of vitamin D according to various protocols (A1-3 and B1-3) for intervention groups	
Follow-up of pregnancy outcomes and neonatal calcium and vitamin D status	Follow-up

Definition of Study Outcomes

In this study the primary outcome was vitamin D deficiency measured as serum level of 25(OH)D and was categorized as: (1) severe deficient (<10ng/ml), (2) moderate deficient, (10-20ng/ml), and (3) normal status (>20ng/ml) [36].

Our secondary outcomes were as follows: Preterm delivery was considered as birth at less than 37 completed weeks of gestation [37]. Miscarriage was referred to as pregnancy loss prior to 20 weeks from LMP [38]. Preeclampsia was defined as systolic blood pressure >140 mmHg or diastolic blood pressure ≥90 mmHg and 24-hour proteinuria ≥0.3 g, started at >20 weeks [39]. Gestational diabetes mellitus referred to glucose intolerance first detected during pregnancy and was diagnosed according to the *International Association of the Diabetes and Pregnancy Study Groups (IADPSG)* criteria [40]. Premature rupture of membrane was considered as rupture of the fetal membranes before the onset of labor regardless of gestational age [41]. By type of delivery, we meant cesarean section or vaginal delivery. Birth weight (gr) was defined as weight at birth irrespective of gestational age [42].

APGAR score comprises 5 components including *appearance, pulse, grimace, activity, and respiration*, each of which is given a score of 0-2 and reported at 1 and 5 minutes after birth [43]. Neonatal icterus was defined as the yellowish discoloration of skin and sclera by bilirubin, usually first noted in the face and then the body [44]. Cord falling off time (day) is the separation time of remained umbilical cord after birth [45].

Season

Blood samples were obtained in spring (April-May), summer (July-September), fall (October-December), and winter (February-March).

Safety Considerations

It has been suggested that vitamin D supplementation can safely be utilized in pregnancy [22]. Furthermore, our study participants who received treatment had vitamin D deficiency and hence, the risk of hypervitaminosis D was reduced to almost zero. Also, during the screening program, any medical condition or probable side effects of vitamin D detected were promptly recorded and discussed by a qualified medical specialist involved in the study.

Approval and Ethical considerations

The protocol was approved by the medical ethics committee of the research institute for endocrine sciences of Shahid Beheshti University of Medical Sciences (10ECRIES25/10/92) (Trial Registration: IRCT2014102519660N1). The reviewers' comments and acceptance letter are provided (see Multimedia Appendices 1-3). Participants were required to sign a written informed consent at recruitment covering all trial procedures and data collection. It was emphasized that participation in the study was voluntary and they were free to withdraw from the study at any time.

Results

Recruitment commenced in July, 2014 and as estimated, nearly 3.5 years is needed to complete the study. Currently, this study is in the stage of analyzing data.

The baseline characteristics of the study participants are shown in Tables 2 and 3, which indicate no significant difference between the participants of the 2 cities.

Table 2. Baseline characteristics of study participants, overall and by study sites.

Characteristics	Masjed-Solayman n=900	Shushtar n=900	Overall n=1800	*P* value[b]
Age (year)	29 (25-32)[a]	29 (25-32)	29 (25-32)	.63
Marriage age (year)	20 (18-22)	19 (17-23)	19 (17-22)	.08
First delivery age (year)	20 (18-22)	20 (18-21)	20 (18-22)	.57
First pregnancy age (year)	21 (19-24)	20 (18-24)	21 (19-24)	.08
Pregnancy week	10 (9-12)	10 (9-12)	9 (10-12)	.07
Gravity	2 (1-3)	2 (1-3)	2 (1-3)	.95
Parity	1 (0-2)	1 (0-2)	1 (0-2)	.86
Number of abortions	0 (0-0)	0 (0-0)	0 (0-0)	.96
Number of children	1 (0-2)	1 (0-2)	1 (0-2)	.79
Vitamin D4 (ng/ml)	11 (7-16)	11 (7-16)	11 (7-16)	.96
SBP (6-10w) (mg/dl)	115 (110-120)	120 (110-120)	120 (110-120)	.87
DPB (6-10w) (mg/dl)	70 (60-70)	70 (70-70)	70 (60-70)	.65
Maternal weight (6-10 w)	65 (59-70)	64 (59-70)	64 (59-70)	.98

[a]Median (interquartile range).

[b]*P* value obtained from independent samples distribution nonparametric Mann-Whitney test (the significance level is <.05).

Table 3. Baseline qualitative characteristics of the study participants, overall and by study site.

Participant characteristics		Masjed Solayman		Shushtar		Overall		
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	[a]*P* value
Education								
	Illiterate	37	4.10	17	1.90	54	3.00	.07
	Primary	132	14.70	135	15.00	267	14.80	
	Guidance school	218	24.20	240	26.70	458	25.40	
	High school	319	35.40	313	34.80	632	35.10	
	Academic	194	21.60	195	21.70	389	21.60	
	Total	900	100.00	900	100.00	1800	100.00	
Spouse education								
	Illiterate	33	3.70	24	2.70	57	3.20	.01[a]
	Primary	136	15.10	144	16.00	280	15.60	
	Guidance school	178	19.80	207	23.00	385	21.40	
	High school	249	27.70	190	21.10	439	24.40	
	Academic	304	33.80	335	37.20	639	35.50	
	Total	900	100.00	900	100.00	1800	100.00	
Spouse occupation								
	Worker	377	41.90	332	36.90	709	39.40	.08
	Clerk	205	22.80	213	23.70	418	23.20	
	Self-employed	318	35.30	355	39.40	673	37.40	
	Total	900	100.00	900	100.00	1800	100.00	
Accommodation								
	Apartment	431	47.90	371	41.20	802	44.60	.004[a]
	House	469	52.10	529	58.80	998	55.40	
	Total	900	100.00	900	100.00	1800	100.00	
Sun exposure								
	<5	319	35.40	264	29.30	583	32.40	.001[a]
	May-15	383	42.60	282	31.30	665	36.90	
	15-30	161	17.90	235	26.10	396	22.00	
	>30	37	4.10	119	13.20	156	8.70	
	Total	900	100.00	900	100.00	1800	100.00	
Cream								
	Mostly	310	34.40	174	19.30	484	26.90	.001[a]
	Sometimes	321	35.60	386	42.90	707	39.20	
	Always	269	29.90	340	37.80	609	33.80	
	Total	900	100.00	900	100.00	1800	100.00	
Sun glass								
	Yes	326	36.20	297	33.00	623	34.60	.15
	No	574	63.80	603	67.00	1177	65.40	
	Total	900	100.00	900	100.00	1800	100.00	
Gloves								

Participant characteristics		Masjed Solayman		Shushtar		Overall		
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	[a]*P* value
	Yes	193	21.40	143	15.90	336	18.70	.002[a]
	No	707	78.60	757	84.10	1464	81.30	
	Total	900	100.00	900	100.00	1800	100.00	
Veil								
	Chador	328	36.40	502	55.80	830	46.10	.001[a]
	Uniform	572	63.60	398	44.20	970	53.90	
	Total	900	100.00	900	100.00	1800	100.00	
Spouse smoke								
	Yes	181	20.10	163	18.10	344	19.10	.28
	No	719	79.90	737	81.90	1456	80.90	
	Total	900	100	900	100.00	1800	100.00	
Occupation								
	Worker	14	1.60	21	2.30	35	1.90	.46
	Clerk	135	15.00	119	13.20	254	14.10	
	Self-employed	111	12.30	117	13.00	228	12.70	
	Housewife	640	71.10	643	71.40	1283	71.30	
	Total	900	100.00	900	100.00	1800	100.00	

[a]The chi-square statistic is significant at the .05 level.

[b]Fisher exact test results is significant at the .05 level.

For the second phase of the study, as statistically was calculated, we needed 800 women, therefore the remaining women were referred to a specialist for further treatments. However, in terms of baseline features except for vitamin D levels, there was no significant difference between the initial sample in Masjed-Soleyman and those who were allocated to intervention (Table 4). The difference for vitamin D is ignorable though.

Table 4. Comparison of baseline characteristics between the initial sample of Masjed-Soleyman participants and those allocated to intervention.

Baseline variables	Initial sample (n=1581)	Allocated for intervention (n=900)	*P* value[a]
Age (year)	29 (25-32)[b]	29 (25-32)	.77
First pregnancy age (year)	20 (18-22)	20 (18-22)	.94
First delivery age (year)	20 (18-22)	20 (18-22)	.73
Gestational age (week)	10 (9-12)	10 (9-12)	.97
Vitamin D	11.9 (8-17)	11.2 (7-16)	.01
Number of children	[b]1 (0-2)	1 (0-2)	.67
Gravity	2 (1-3)	2 (1-3)	.62
Parity	1 (0-2)	1 (0-2)	.47
Number of abortions	0 (0-0)	0 (0-0)	.94

[a]*P* value obtained from nonparametric Mann-Whitney test for nonnormal variables.

[b]Median (interquartile range, Q1-Q3).

Discussion

Principal Findings

Vitamin D deficiency is one of the most prevalent disorders among mothers and children [26]. Although in the past few decades, early diagnosis of vitamin D deficiency and availability of supplementations and treatment modalities have improved the deficiency condition; hypovitaminosis D still exists as a major public health concern associated with significant morbidities in a variety of countries [23]. Unfortunately, among Iranian women who have sunlight exposure deprivation and inadequate dietary vitamin D intake, it is highly prevalent. Reports indicate that 86% of Iranian pregnant women and 75% of their newborns suffer from vitamin D deficiency [46].

Despite the safety of maternal supplementation in preventing vitamin D deficiency during pregnancy, at the moment there is no certain preventive or interventive strategy to ensure maternal vitamin D sufficiency. Therefore, the effect of vitamin D supplementation in pregnant women remains an arguable problem.

In a double-blind randomized clinical trial, Hollis et al [47] determined the safety and efficacy of vitamin D supplementation in pregnant women. In that study, 350 first trimester pregnant women received 400, 2000, or 4000 IU of vitamin D per day until delivery. The relative risk (RR) of vitamin D deficiency was significantly different between the groups receiving 2000 and 400 IU (RR=1.52, 95% CI 1.24-1.86) and the groups receiving the 4000 and 400 IU (RR=1.60, 95% CI 1.32-1.95). Difference was not significant between 4000 and 2000 IU groups (RR=1.06, 95% CI 0.93-1.19). They concluded that vitamin D supplementation of 4000 IU/d for pregnant women is safe and most effective in achieving sufficiency in all women and their neonates, irrespective of race and ethnicity. The optimization of 25(OH)D and $1,25(OH)_2$ D levels was attained without any evidence of hypervitaminosis or increase in adverse side effects during pregnancy.

In a recent study, Mojibian et al investigated the effects of 50,000 IU of vitamin D every 2 weeks supplementation on the incidence of maternal and neonatal outcomes and compared it with the women who received 400 IU vitamin D per day. They reported that there were no differences in the incidence of maternal outcomes (preeclampsia, gestational hypertension, preterm labor, and low birth weight) and anthropometric measures in neonates between two groups except for gestational diabetes mellitus (GDM), which was significantly lower in the first group. They concluded that vitamin D supplementation with a dose of 50,000 IU vitamin D every 2 weeks could decrease the incidence of GDM [48]. In an accordant study, Rodda et al conducted an open-label randomized controlled trial and reported the preventive effects of vitamin D supplementation in neonatal deficiency among deficient mothers [49].

Nevertheless, in a systematic review by Harvey et al [20], authors reported insufficient evidence to support clinical recommendations regarding vitamin D supplementation in pregnancy. They concluded that although there may be a relationship between maternal 25(OH)D levels with newborn birth weight and bone mass, there is a risk of bias and therefore further randomized clinical trials are needed. Another recent systematic review by De-Regil et al [22] revealed that supplementing pregnant women with vitamin D in a single or continued dose increases serum 25(OH)D at term and may reduce the risk of preeclampsia, low birth weight, and preterm birth. However, the evidence on whether vitamin D supplementation should be given as a part of routine antenatal care to all women to improve maternal and infant outcomes remains unclear.

At present, novel investigations, specifically, randomized controlled trials are needed to assess the optimal vitamin D requirements of pregnant women particularly in high-risk populations with inadequate sunlight exposure. The present survey will address an attempt to update the optimal strategies on treatment or supplementation of vitamin D deficiency during pregnancy.

Limitations

However, this study is subject to some limitations. First, conducting the study in urban regions restricts its generalizability to rural areas. Second, some pregnancies may be aborted prior to entering the study and hence it could decrease our power to interpret the results of miscarriage outcome. Third, the potential number of our lost to follow-up cases may be another limitation. Finally, fourth is the concern of vitamin D consumption or lack of adherence to the treatment regimen among the intervention groups.

Overall, the results of this study regarding vitamin D deficiency prevalence and optimal supplementation and treatment methods during pregnancy will empower clinicians with novel recommendations in patient decision-making.

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Authors' Contributions

MR participated in the study conception and design; data collection; and carried out the samples analysis, interpretation of data, and drafting the manuscript. FRT participated in the study conception and design, carried out the samples analysis, interpretation of data, managed the literature search, and drafting the manuscript. MS participated in the study conception and design, carried

out the samples analysis, interpretation of data, managed the literature search, drafting the manuscript, and critical revision. FHP participated in the study design, helped to draft the manuscript and sample analysis. HAM participated in the study design, carried out the samples analysis and interpretation of data, and drafting the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Reviewers' comments.

[PDF File (Adobe PDF File), 4MB - resprot_v6i4e54_app1.pdf]

Multimedia Appendix 2

Response to reviewers.

[PDF File (Adobe PDF File), 226KB - resprot_v6i4e54_app2.pdf]

Multimedia Appendix 3

Acceptance letter.

[PDF File (Adobe PDF File), 134KB - resprot_v6i4e54_app3.pdf]

Multimedia Appendix 4

CONSORT-eHEALTH (V 1.6.1) - submission/publication form.

[PDF File (Adobe PDF File), 76KB - resprot_v6i4e54_app4.pdf]

References

1. Christakos S, Dhawan P, Verstuyf A, Verlinden L, Carmeliet G. Vitamin D: metabolism, molecular mechanism of action, and pleiotropic effects. Physiol Rev 2016 Jan;96(1):365-408. [doi: 10.1152/physrev.00014.2015] [Medline: 26681795]
2. Nair R, Maseeh A. Vitamin D: The “sunshine” vitamin. J Pharmacol Pharmacother 2012 Apr;3(2):118-126 [FREE Full text] [doi: 10.4103/0976-500X.95506] [Medline: 22629085]
3. Weaver CM. Vitamin D, calcium homeostasis, and skeleton accretion in children. J Bone Miner Res 2007 Dec;22(Suppl 2):V45-V49 [FREE Full text] [doi: 10.1359/jbmr.07s201] [Medline: 18290721]
4. Pertile RA, Cui X, Eyles DW. Vitamin D signaling and the differentiation of developing dopamine systems. Neuroscience 2016 Oct 01;333:193-203. [doi: 10.1016/j.neuroscience.2016.07.020] [Medline: 27450565]
5. Kikuta J, Ishii M. [Current Topics on Vitamin D. The effects of vitamin D on the immune system]. Clin Calcium 2015 Mar;25(3):359-365.
6. Korf H, Decallonne B, Mathieu C. Vitamin D for infections. Curr Opin Endocrinol Diabetes Obes 2014 Dec;21(6):431-436. [doi: 10.1097/MED.0000000000000108] [Medline: 25354043]
7. Jacobs ET, Kohler LN, Kunihiro AG, Jurutka PW. Vitamin D and colorectal, breast, and prostate cancers: a review of the epidemiological evidence. J Cancer 2016;7(3):232-240 [FREE Full text] [doi: 10.7150/jca.13403] [Medline: 26918035]
8. Wang TJ. Vitamin D and cardiovascular disease. Annu Rev Med 2016;67:261-272. [doi: 10.1146/annurev-med-051214-025146] [Medline: 26768241]
9. Ringe JD. The effect of Vitamin D on falls and fractures. Scand J Clin Lab Invest Suppl 2012;243:73-78. [doi: 10.3109/00365513.2012.681965] [Medline: 22536766]
10. Rosen Y, Daich J, Soliman I, Brathwaite E, Shoenfeld Y. Vitamin D and autoimmunity. Scand J Rheumatol 2016 Nov;45(6):439-447. [doi: 10.3109/03009742.2016.1151072] [Medline: 27191042]
11. Nakashima A, Yokoyama K, Yokoo T, Urashima M. Role of vitamin D in diabetes mellitus and chronic kidney disease. World J Diabetes 2016 Mar 10;7(5):89-100 [FREE Full text] [doi: 10.4239/wjd.v7.i5.89] [Medline: 26981182]
12. Okereke OI, Singh A. The role of vitamin D in the prevention of late-life depression. J Affect Disord 2016 Jul 01;198:1-14. [doi: 10.1016/j.jad.2016.03.022] [Medline: 26998791]
13. Liu N, Kaplan AT, Low J, Nguyen L, Liu GY, Equils O, et al. Vitamin D induces innate antibacterial responses in human trophoblasts via an intracrine pathway. Biol Reprod 2009 Mar;80(3):398-406 [FREE Full text] [doi: 10.1095/biolreprod.108.073577] [Medline: 19005165]
14. Kovacs CS. Maternal vitamin D deficiency: fetal and neonatal implications. Semin Fetal Neonatal Med 2013 Feb 13 Epub ahead of print. [doi: 10.1016/j.siny.2013.01.005] [Medline: 23415843]

15. Kaushal M, Magon N. Vitamin D in pregnancy: a metabolic outlook. Indian J Endocrinol Metab 2013 Jan;17(1):76-82 [FREE Full text] [doi: 10.4103/2230-8210.107862] [Medline: 23776856]
16. Eyles D, Burne T, McGrath J. Vitamin D in fetal brain development. Semin Cell Dev Biol 2011 Aug;22(6):629-636. [doi: 10.1016/j.semcdb.2011.05.004] [Medline: 21664981]
17. Aly YF, El Koumi MA, Abd El Rahman Rehab N. Impact of maternal vitamin D status during pregnancy on the prevalence of neonatal vitamin D deficiency. Pediatr Rep 2013 Feb 05;5(1):e6 [FREE Full text] [doi: 10.4081/pr.2013.e6] [Medline: 23667735]
18. Naghshineh E, Sheikhaliyan S. Effect of vitamin D supplementation in the reduce risk of preeclampsia in nulliparous women. Adv Biomed Res 2016;5:7 [FREE Full text] [doi: 10.4103/2277-9175.175239] [Medline: 26962509]
19. Burris HH, Camargo CA. Vitamin D and gestational diabetes mellitus. Curr Diab Rep 2014 Jan;14(1):451 [FREE Full text] [doi: 10.1007/s11892-013-0451-3] [Medline: 24277676]
20. Harvey NC, Holroyd C, Ntani G, Javaid K, Cooper P, Moon R, et al. Vitamin D supplementation in pregnancy: a systematic review. Health Technol Assess 2014 Jul;18(45):1-190 [FREE Full text] [doi: 10.3310/hta18450] [Medline: 25025896]
21. Viljakainen HT, Saarnio E, Hytinantti T, Miettinen M, Surcel H, Mäkitie O, et al. Maternal vitamin D status determines bone variables in the newborn. J Clin Endocrinol Metab 2010 Apr;95(4):1749-1757. [doi: 10.1210/jc.2009-1391] [Medline: 20139235]
22. De-Regil LM, Palacios C, Lombardo LK, Peña-Rosas JP. Vitamin D supplementation for women during pregnancy. Cochrane Database Syst Rev 2016 Jan 14(1):CD008873. [doi: 10.1002/14651858.CD008873.pub3] [Medline: 26765344]
23. Cashman KD, Dowling KG, Škrabáková Z, Gonzalez-Gross M, Valtueña J, De Henauw S, et al. Vitamin D deficiency in Europe: pandemic? Am J Clin Nutr 2016 Apr;103(4):1033-1044 [FREE Full text] [doi: 10.3945/ajcn.115.120873] [Medline: 26864360]
24. Karras SN, Fakhoury H, Muscogiuri G, Grant WB, van den Ouweland JM, Colao AM, et al. Maternal vitamin D levels during pregnancy and neonatal health: evidence to date and clinical implications. Ther Adv Musculoskelet Dis 2016 Aug;8(4):124-135 [FREE Full text] [doi: 10.1177/1759720X16656810] [Medline: 27493691]
25. Al-Faris NA. High prevalence of vitamin D deficiency among pregnant Saudi women. Nutrients 2016 Feb 04;8(2):77 [FREE Full text] [doi: 10.3390/nu8020077] [Medline: 26861386]
26. Vandevijvere S, Amsalkhir S, Van Oyen H, Moreno-Reyes R. High prevalence of vitamin D deficiency in pregnant women: a national cross-sectional survey. PLoS One 2012;7(8):e43868 [FREE Full text] [doi: 10.1371/journal.pone.0043868] [Medline: 22937114]
27. Choi R, Kim S, Yoo H, Cho YY, Kim SW, Chung JH, et al. High prevalence of vitamin D deficiency in pregnant Korean women: the first trimester and the winter season as risk factors for vitamin D deficiency. Nutrients 2015 May 11;7(5):3427-3448 [FREE Full text] [doi: 10.3390/nu7053427] [Medline: 25970148]
28. Rodríguez-Dehli AC, Riaño GI, Fernández-Somoano A, Navarrete-Muñoz EM, Espada M, Vioque J, et al. [Prevalence of vitamin d deficiency and insuffiency and associated factors in pregnant women of northern Spain]. Nutr Hosp 2015 Apr 01;31(4):1633-1640 [FREE Full text] [doi: 10.3305/nh.2015.31.4.8448] [Medline: 25795951]
29. Pirdehghan A, Vakili M, Dehghan R, Zare F. High prevalence of vitamin D deficiency and adverse pregnancy outcomes in Yazd, a central province of Iran. J Reprod Infertil 2016 Jan;17(1):34-38 [FREE Full text] [Medline: 26962481]
30. Salek M, Hashemipour M, Aminorroaya A, Gheiratmand A, Kelishadi R, Ardestani PM, et al. Vitamin D deficiency among pregnant women and their newborns in Isfahan, Iran. Exp Clin Endocrinol Diabetes 2008 Jun;116(6):352-356. [Medline: 18700279]
31. Abbasian M, Chaman R, Amiri M, Ajami ME, Jafari-Koshki T, Rohani H, et al. Vitamin D deficiency in pregnant women and their neonates. Glob J Health Sci 2016 Dec 01;8(9):54008 [FREE Full text] [doi: 10.5539/gjhs.v8n9p83] [Medline: 27157170]
32. Urrutia RP, Thorp JM. Vitamin D in pregnancy: current concepts. Curr Opin Obstet Gynecol 2012 Mar;24(2):57-64 [FREE Full text] [doi: 10.1097/GCO.0b013e3283505ab3] [Medline: 22327734]
33. Kernan WN, Viscoli CM, Makuch RW, Brass LM, Horwitz RI. Stratified randomization for clinical trials. J Clin Epidemiol 1999 Jan;52(1):19-26. [Medline: 9973070]
34. Probst P, Grummich K, Heger P, Zaschke S, Knebel P, Ulrich A, et al. Blinding in randomized controlled trials in general and abdominal surgery: protocol for a systematic review and empirical study. Syst Rev 2016 Mar 24;5:48 [FREE Full text] [doi: 10.1186/s13643-016-0226-4] [Medline: 27012940]
35. Appelgren KE, Nietert PJ, Hulsey TC, Hollis BW, Wagner CL. Analyzing adherence to prenatal supplement: does pill count measure up? Int J Endocrinol 2010;2010:631971 [FREE Full text] [doi: 10.1155/2010/631971] [Medline: 20169132]
36. Kennel KA, Drake MT, Hurley DL. Vitamin D deficiency in adults: when to test and how to treat. Mayo Clin Proc 2010 Aug;85(8):752-7; quiz 757 [FREE Full text] [doi: 10.4065/mcp.2010.0138] [Medline: 20675513]
37. Behrman R, Butler A. Preterm birth: causes, consequences, and prevention. Washington, DC: National Academies Press; 2007.
38. Ford HB, Schust DJ. Recurrent pregnancy loss: etiology, diagnosis, and therapy. Rev Obstet Gynecol 2009;2(2):76-83. [Medline: 19609401]

39. Uzan J, Carbonnel M, Piconne O, Asmar R, Ayoubi J. Pre-eclampsia: pathophysiology, diagnosis, and management. Vasc Health Risk Manag 2011;7:467-474 [FREE Full text] [doi: 10.2147/VHRM.S20181] [Medline: 21822394]
40. Laafira A, White SW, Griffin CJ, Graham D. Impact of the new IADPSG gestational diabetes diagnostic criteria on pregnancy outcomes in Western Australia. Aust N Z J Obstet Gynaecol 2016 Feb;56(1):36-41. [doi: 10.1111/ajo.12394] [Medline: 26293845]
41. Caughey AB, Robinson JN, Norwitz ER. Contemporary diagnosis and management of preterm premature rupture of membranes. Rev Obstet Gynecol 2008;1(1):11-22. [Medline: 18701929]
42. Feresu SA, Harlow SD, Woelk GB. Risk factors for low birthweight in Zimbabwean women: a secondary data analysis. PLoS One 2015;10(6):e0129705 [FREE Full text] [doi: 10.1371/journal.pone.0129705] [Medline: 26114867]
43. American Academy of Pediatrics, Committee on Fetus and Newborn, American College of Obstetricians and Gynecologists and Committee on Obstetric Practice. The Apgar score. Pediatrics 2006 Apr;117(4):1444-1447. [doi: 10.1542/peds.2006-0325] [Medline: 16585348]
44. Ogunfowora OB, Daniel OJ. Neonatal jaundice and its management: knowledge, attitude and practice of community health workers in Nigeria. BMC Public Health 2006 Jan 27;6:19 [FREE Full text] [doi: 10.1186/1471-2458-6-19] [Medline: 16441888]
45. Quattrin R, Iacobucci K, De Tina AL, Gallina L, Pittini C, Brusaferro S. 70% alcohol versus dry cord care in the umbilical cord care: a case-control study in Italy. Medicine (Baltimore) 2016 Apr;95(14):e3207 [FREE Full text] [doi: 10.1097/MD.0000000000003207] [Medline: 27057849]
46. Kazemi A, Sharifi F, Jafari N, Mousavinasab N. High prevalence of vitamin D deficiency among pregnant women and their newborns in an Iranian population. J Womens Health (Larchmt) 2009 Jun;18(6):835-839. [doi: 10.1089/jwh.2008.0954] [Medline: 19514825]
47. Hollis BW, Johnson D, Hulsey TC, Ebeling M, Wagner CL. Vitamin D supplementation during pregnancy: double-blind, randomized clinical trial of safety and effectiveness. J Bone Miner Res 2011 Oct;26(10):2341-2357 [FREE Full text] [doi: 10.1002/jbmr.463] [Medline: 21706518]
48. Mojibian M, Soheilykhah S, Fallah Zadeh MA, Jannati MM. The effects of vitamin D supplementation on maternal and neonatal outcome: a randomized clinical trial. Iran J Reprod Med 2015 Nov;13(11):687-696 [FREE Full text] [Medline: 26730243]
49. Rodda CP, Benson JE, Vincent AJ, Whitehead CL, Polykov A, Vollenhoven B. Maternal vitamin D supplementation during pregnancy prevents vitamin D deficiency in the newborn: an open-label randomized controlled trial. Clin Endocrinol (Oxf) 2015 Sep;83(3):363-368. [doi: 10.1111/cen.12762] [Medline: 25727810]

Abbreviations

25(OH)D: 25-hydroxyvitamin D
APGAR: appearance, pulse, grimace, activity, respiration
DBP: diastolic blood pressure
GDM: gestational diabetes mellitus
IQR: interquartile range
IU: international unit
RR: relative risk
SBP: systolic blood pressure
SD: standard deviation

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Protocol

The Smartphone Peer Physical Activity Counseling (SPPAC) Program for Manual Wheelchair Users: Protocol of a Pilot Randomized Controlled Trial

Krista L Best[1,2], PhD; François Routhier[1,2], PEng, PhD; Shane N Sweet[3,4], PhD; Kelly P Arbour-Nicitopoulos[5], PhD; Jaimie F Borisoff[6,7], PhD; Luc Noreau[1,2], PhD; Kathleen A Martin Ginis[8], PhD

[1]Department of Rehabilitation, Université Laval, Quebec City, QC, Canada

[2]Centre for interdisciplinary research in rehabilitation and social integration, Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale, Institut de réadaptation en déficience physique de Québec, Quebec City, QC, Canada

[3]Department of Kinesiology and Physical Education, McGill University, Montreal, QC, Canada

[4]Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain (CRIR)., Montréal, QC, Canada

[5]Faculty of Kinesiology and Physical Education, University of Toronto, Toronto, ON, Canada

[6]International Collaboration on Repair Discoveries (ICORD), Vancouver, BC, Canada

[7]Rehabilitation Engineering Design Laboratory, British Columbia Institute of Technology, Burnaby, BC, Canada

[8]Department of Kinesiology, University of British Columbia (Okanagan), Kelowna, BC, Canada

Corresponding Author:
François Routhier, PEng, PhD
Centre for interdisciplinary research in rehabilitation and social integration
Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Institut de réadaptation en déficience physique de Québec
525, boulevard Wilfrid-Hamel
Quebec City, QC, G1M 2S8
Canada
Phone: 1 418 529 9141 ext 6256
Email: francois.routhier@rea.ulaval.ca

Abstract

Background: Physical activity (PA) must be performed regularly to accrue health benefits. However, the majority of manual wheelchair users do not meet PA recommendations. Existing community-based PA programs for manual wheelchair users appear to work, but effect sizes are small and retention is low. Existing PA programs may not fully implement some psychosocial factors that are strongly linked with PA (eg, autonomy). The use of peers and mobile phone technology in the Smartphone Peer PA Counseling (SPPAC) program represents a novel approach to cultivating a PA-supportive environment for manual wheelchair users.

Objective: The primary objective is to compare change in objective PA between the experimental (SPPAC) and control groups from baseline to postintervention (10 weeks) and follow-up (3 months). Changes in and relationships between subjective PA, wheelchair skills, motivation, self-efficacy (for overcoming barriers to PA for manual wheelchair use), satisfaction of psychological needs for PA, and satisfaction with PA participation will be explored (secondary outcome). Program implementation will be explored (tertiary objective).

Methods: A total of 38 community-living manual wheelchair users (≥18 years) will be recruited in a randomized controlled trial (RCT). Participants in both the control and experimental groups will receive existing PA guidelines. Participants in the experimental group will also receive the SPPAC program: 14 sessions (~30 min) over a 10-week period delivered by a peer trainer using a mobile phone. PA activities will be based on individuals' preferences and goals. Implementation of important theoretical variables will be enforced through a peer-trainer checklist. Outcomes for objective PA (primary) and subjective PA, wheelchair skills, motivation, self-efficacy, satisfaction of psychological needs, and satisfaction with participation will be collected at three time points (baseline, postintervention, follow-up). Multiple imputations will be used to treat missing data. A mixed-model ANCOVA will be conducted, controlling for covariates (primary and secondary objectives). The strength and direction of the relationships between the primary and secondary outcomes will be explored (secondary objective). Descriptive and content analysis will be used to appraise program implementation (tertiary objective).

Results: Funding has been obtained from the Craig Neilsen Foundation and the Canadian Disability Participation Project, with additional funds being sought from the Canadian Institute for Health Research and Fonds de Recherche du Québec-Santé. Pilot evaluation of intervention implementation is currently underway, with enrollment anticipated to begin early 2018.

Conclusions: There may be substantial benefits for the SPPAC program including limited burden on health care professionals, decreased barriers (eg. accessibility, transportation), development of peer social supports, and potential cost savings related to physical inactivity. Before conducting a large and expensive multisite RCT within a small heterogeneous population of manual wheelchair users, a pilot study affords a prudent step to establishing an adequate study protocol and implementation strategies.

Trial Registration: ClinicalTrials.gov NCT02826707; https://clinicaltrials.gov/ct2/show/NCT02826707 (Archived by WebCite at http://www.webcitation.org/6pqIc14dU)

(JMIR Res Protoc 2017;6(4):e69) doi:10.2196/resprot.7280

KEYWORDS

Manual wheelchair; Physical activity; Peer training; Smartphone; Randomized controlled trial

Introduction

Despite numerous physical (eg, functioning), psychological (eg, quality of life), and social (eg, inclusion) benefits of physical activity (PA) [1], more than 55% of adults (18-74 years) and 90% of older adults (≥60 years) who use wheelchairs are not physically active enough to accrue health benefits [2,3]. The sedentary nature of sitting in a wheelchair can trigger a chain of negative physiological and psychological events that can exacerbate physical, psychosocial, and mental sequelae overtime [4]. Therefore, the health benefits of PA may be amplified for manual wheelchair users [5,6]. For instance, even moderate amounts of PA could optimize functioning and slow the spiraling effects of deconditioning that are associated with disability [7].

Compared to the general adult population, manual wheelchair users face additional barriers to PA participation, including complex health problems [8], lack of accessible spaces, transportation challenges [9], and financial stress [10]. Thus, a need for accessible and affordable PA interventions for manual wheelchair users has been documented [10]. Successful community-based programs have addressed many of these facilitators and barriers for manual wheelchair users using various behavioral approaches (eg, Workout on Wheels [10]), and individuals with spinal cord injury, who account for approximately 80% of manual wheelchair users (eg, Get in Motion [11] and home visits [12]) with variable effects on PA. Two randomized controlled trials (RCTs) of interventions that used health care professionals to prescribe PA (ie, Workout on Wheels and Get in Motion) had small effect sizes on PA [10,11]. Although cofacilitation of a home-based strength-training program by a health care professional and peer trainer had a large effect on PA (ie, strength training), findings of this study are limited by a small sample size and lack of a control group [12].

Existing community-based PA programs have implemented important variables that are known to influence PA (eg, coping, action planning, and self-efficacy). However, participant retention was less than 75% and there was little documentation of PA maintenance over time. One explanation may be that participants in these programs were generally prescribed exercise-type activities (ie, aerobic and strength-training exercises), which may have limited their perceived choice in the activities performed (ie, an important predictor of PA uptake and adherence) [13]. Arguably, improving participation in meaningful activities that require any movement may be considered PA and even small improvements in PA may have a profound impact for manual wheelchair users. Therefore, providing manual wheelchair users with choice in activities represents an important consideration.

Motivations for uptake and maintenance of PA occur through complex psychological processes. Consideration of a multitude of psychosocial variables linked with PA (eg, autonomy, motivation, self-efficacy) is required to elicit large effects on PA that result in sustainable behavior change [14-16]. Self-determination theory provides a framework for cultivating an autonomy-supportive social environment that promotes behavior change through the facilitation of the three basic psychological needs of autonomy (ie, feeling free to choose one's own behavior), competence (ie, interacting effectively with one's environment by mastering challenging tasks), and relatedness (ie, feeling meaningfully connected to others within one's social group) [13-15]. Satisfaction of these basic psychological needs will lead to greater intrinsic motivation [14]. An autonomous supportive environment positively influences behavior change [17], including uptake and adherence to PA [18]. Additionally, self-efficacy (ie, an individual's situation-specific belief in his or her capability to accomplish a given task or behavior) is one of the most salient factors in predicting uptake and maintenance of PA [16,19,20]. Although perceived competence (from self-determination theory) and self-efficacy are often used interchangeably, a clear distinction between the two concepts has been made [21]. Therefore, distinguishing between competence and self-efficacy may have important implications for better understanding the psychological mechanisms driving changes in PA behavior [21].

The tenets of social cognitive theory provide a useful theoretical lens for incorporating self-efficacy into PA interventions [19,20]. Accordingly, self-efficacy is informed by skill mastery, vicarious experience, verbal persuasion, and reinterpretation of physiological and affective symptoms [16]. Although skill mastery is the most salient of these four sources, interventions that also include vicarious experience have been shown to enhance effects on PA behavior [22]. Therefore, considering integration of theoretical factors from both self-determination and social cognitive theories represents a useful approach to

tailor the specific needs of manual wheelchair users for the uptake and maintenance of PA [18].

Targeting the important theoretical factors through strategic program implementation provides one way to cultivate an autonomy-supportive environment that enhances autonomy, motivation, and self-efficacy. First, allowing individuals to choose how they participate in meaningful activities may foster a sense of perceived autonomy, which is important for enjoyment and maintenance of the behavior [13]. Second, interventions led by a peer (ie, a person who has experiential knowledge of a specific behavior and similar characteristics as the target population [23]), can enhance self-efficacy and relatedness through vicarious experiences and shared characteristics. Peers provide an effective context for modeling because they are managing comparable conditions, have experienced similar situations, and are credible [24-26]. Adults try harder and experience higher levels of learning when they learn from individuals who have perceived similarities [27]. Peers have effectively increased PA in both clinical and community settings [12,28-30], and improved manual wheelchair skills in community-living adults [31].

Finally, telephone counseling represents an accessible and affordable approach to PA counseling with promising results for increasing PA among manual wheelchair users [10,11]. Opportunely, mobile phones are becoming ubiquitous and afford greater accessibility and convenience for manual wheelchair users. The use of mobile phones for PA counseling may further target autonomy, motivations, and self-efficacy. For example, the use of mobile phones to deliver a PA intervention offers various methods of contact (eg, voice calls, video calls), which may promote personal choice and autonomy. Video calls would enable face-to-face interactions with a peer, which may further enhance self-efficacy and relatedness through vicarious experience. Additionally, social support created by using existing social apps (eg, Facebook) for communicating with peers and monitoring PA goals may provide an avenue for enhancing motivation and self-efficacy [32,33]. For example, results from a recent RCT showed online social networks comprised of like individuals had larger effects on PA than receiving promotional PA messages from a website, and at a much lower cost [33]. Although the source of motivation that arises through online social networks was unclear, the authors suggested that even minimal exposure to online social cues could have a profound influence on PA [33].

The Smartphone Peer Physical Activity Counseling (SPPAC) program will use the power of peers and technology to foster critical psychosocial constructs as a precursor to PA (ie, autonomy, motivation, self-efficacy) providing a potential solution for delivery of broad-reaching and accessible PA intervention for manual wheelchair users with minimal costs. The proposed study protocol will evaluate the efficacy of the SPPAC program for improving PA in manual wheelchair users through a pilot RCT. Based on changes in PA in the intervention group compared to the control group, the primary objective is to provide effect size estimates of the SPPAC intervention on objective PA from baseline to postintervention (10 weeks) and at follow-up (3 months postintervention). Secondary objectives include exploratory evaluation of changes and relationships in subjective PA, wheelchair skills, motivation, self-efficacy (for overcoming barriers to PA, for manual wheelchair use), satisfaction of psychological needs for PA, and satisfaction with participation in PA. Finally, implementation of the SPPAC program will be examined.

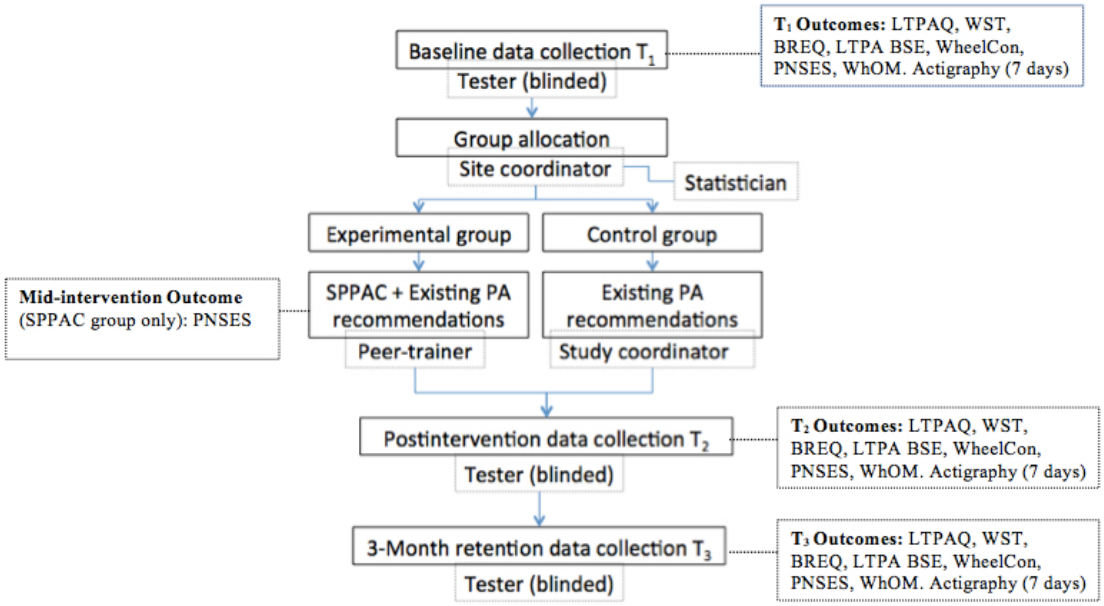
Methods

Trial Design

A two-site (Montreal and Quebec City, QC, Canada), single-blind, pilot RCT will be done to evaluate the efficacy of the SPPAC intervention for increasing PA in an experimental group versus a control group. Participants will be randomly assigned to the experimental group (SPPAC) or the control group (existing PA resources for manual wheelchair users) using a 1:1 allocation ratio (Figure 1). A statistician who is not part of the study team will perform randomization procedures using an undisclosed block size that is stratified by site (19 per site).

After consent and enrollment, a research assistant (RA; research professional with at least 2 years experience in clinical research) will collect baseline data and enter it into a secure database. A research coordinator will inform the statistician of enrollment via telephone or email and will obtain group assignment within 48 hours. The research coordinator will then forward the participants' contact information to a peer trainer (experimental) and will forward PA recommendations to both groups. To reduce the risk of bias, participants will be instructed not to discuss the study with the RAs (two per site), who will be blinded to group allocation. Experimental group participants will complete 14 SPPAC sessions over 10 weeks [34]. Participants in both groups will receive usual care (ie, existing PA resources/recommendations) [35].

Figure 1. Detailed description of the Smartphone Peer Physical Activity Counseling (SPPAC) trial design and outcome assessment. HADS: Hospital Anxiety and Depression Scale, ISEL: Interpersonal Support Evaluation List, BREQ-2: Behavioral Regulation in Exercise Questionnaire-2; LTPA BSE: Leisure-Time Physical Activity Barriers Self-Efficacy scale; LTPAQ: Leisure-Time Physical Activity Questionnaire; PNSES: Psychological Need Satisfaction in Exercise Scale; WheelCon: Wheelchair Use Confidence Scale; WhOM: Wheelchair Outcome Measure; WST: Wheelchair Skills Test.



Ethics

The protocol for this study was approved by the Research Ethics Boards of the Institut de réadaptation en déficience physique de Québec (IRDPQ). The study protocol was registered (NCT02826707). All study participants will provide informed consent.

Participants

A total of 38 community-dwelling manual wheelchair users will be recruited on a volunteer basis from three large outpatient rehabilitation hospitals (IRDPQ, Jewish Rehabilitation Hospital [JRH], and Institut de réadaptation Gingras-Lindsay-de-Montréal [IRGLM]) and from two adapted fitness centers (Adaptavie, VioMax). Clinicians at the IRDPQ, JRH, and IRGLM who are part of the researchers' respective teams will identify potential participants, whereas the fitness centers (Adaptavie, VioMax) will send information to their members by email/mail and word-of-mouth. Collaboration with Adaptavie and VioMax will also facilitate recruitment of peer trainers and may provide an avenue for sustainability of the SPPAC program in the future. Based on our past experiences in recruiting manual wheelchair users, this recruitment strategy is reasonable [1,31,36].

Participants will be between 18 and 65 years [35], live in the community, use a manual wheelchair for mobility, have used a manual wheelchair for 1 month or more, able to self-propel a manual wheelchair for at least 100 m, not be currently meeting the PA guidelines [35], able to communicate in English or French, and cognitively able to engage in the SPPAC intervention. Individuals will be excluded if they have a degenerative condition that is expected to progress quickly (eg, amyotrophic lateral sclerosis). Readiness for PA will be screened using the validated Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and the electronic Physical Activity Readiness Medical Examination (ePARmed-X+) [37,38].

Sample Size

Based on variability data (mean, standard deviation) from Nooijen et al [39], 30 participants will be required to detect a 28-minute difference per day in PA between the experimental group and the control group (beta=.20, alpha=.05). A sample size calculation for ANCOVA in RCT designs was performed using G*power [40]. Because Arbour-Nicitopoulos et al [11] reported a 26% dropout rate in a telephone-delivered PA intervention for people living with spinal cord injury, the sample size was increased accordingly (total N=38).

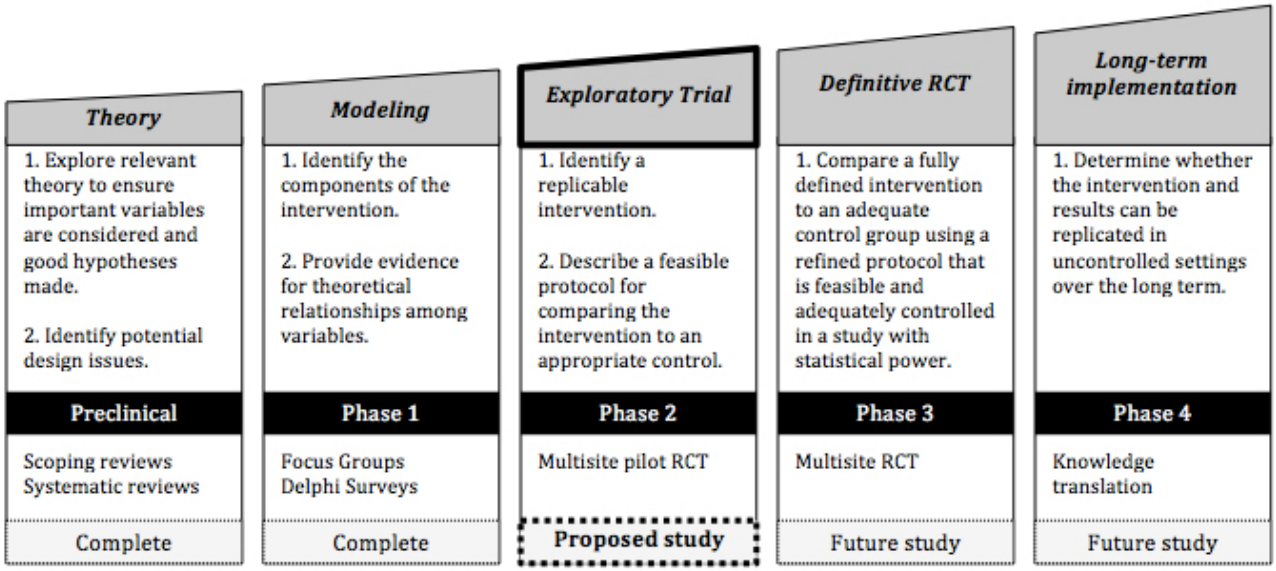
Procedure

Outcome measures will be collected at baseline (T1=prerandomization), postintervention (T2=minimum of 2 days and maximum of 10 days), and at 3-month follow-up (T3=retention) (Figure 1). Experimental bias will be minimized by having two trained RAs at each site (one will administer T1 assessments and one will administer T2 and T3 assessments).

Intervention

According to the Medical Research Council (MRC) framework for developing complex interventions [41], the SPPAC was established through systematic reviews and refined through focus groups and Delphi surveys with experts [34] (Figure 2). A pilot RCT is a pragmatic next step in the MRC framework to evaluate the efficacy of SPPAC for increasing PA and understanding the influence of important theoretical variables for manual wheelchair users (Figure 1).

Figure 2. The proposed study according to the five-step process described by the Medical Research Council framework for developing complex interventions [42].



Experimental Group: Smartphone Peer Physical Activity Counseling

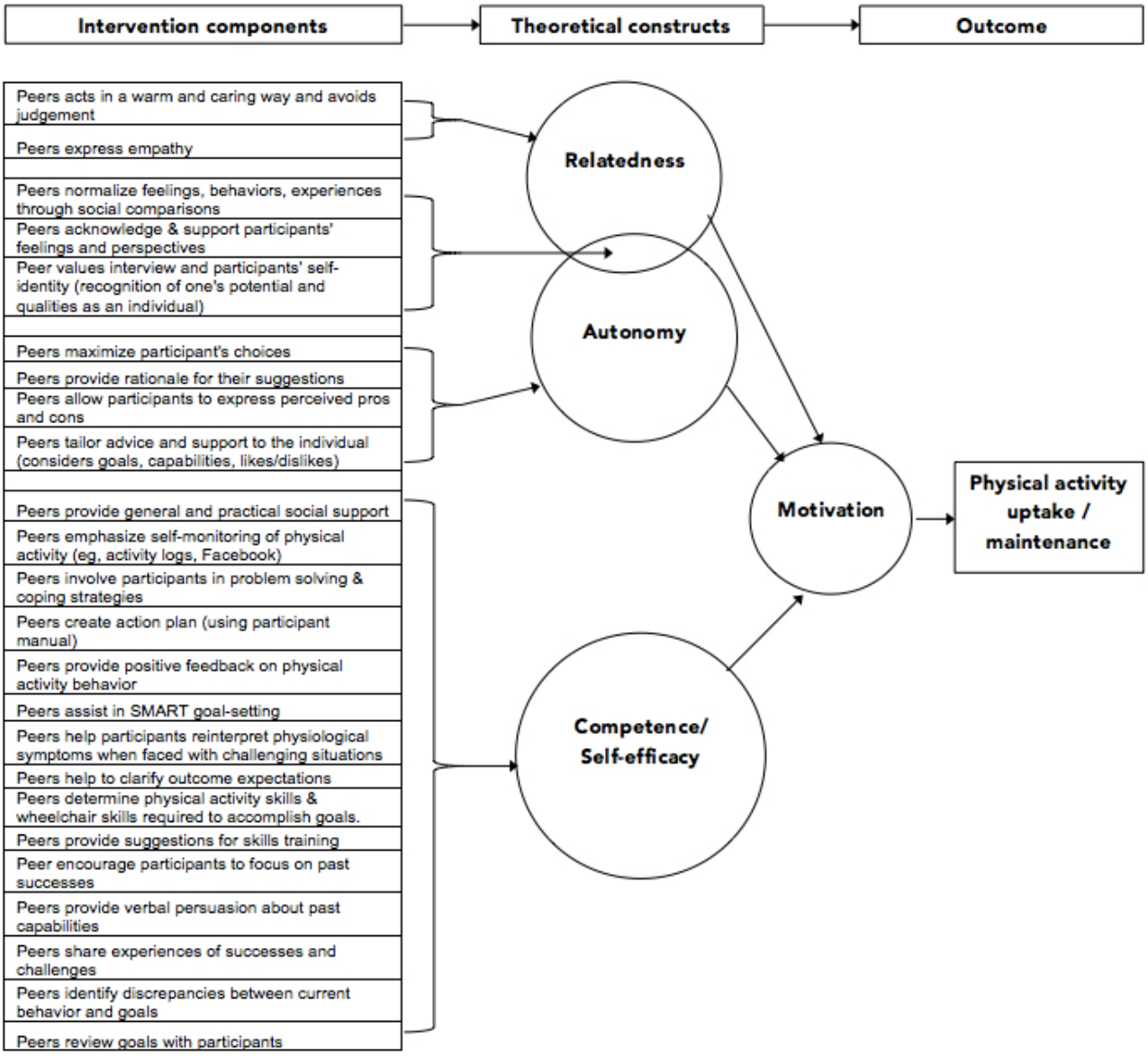
The SPPAC program comprises 14 weekly sessions (~30 min) delivered by a peer trainer over 10 weeks. Feedback from focus groups indicated a desire for increased frequency of contact at the beginning and end of program; therefore, two sessions per week will be held during weeks 1 through 3 and week 10 [34]. Peer trainers, who are physically active manual wheelchair users with at least 5 years' experience using a manual wheelchair, will consult a study investigator throughout program implementation as needed. A minimum of two peer trainers will receive comprehensive training in a 2-day workshop from study investigators (KB, KAN, SS) that will include education about adapted PA, PA using a manual wheelchair, manual wheelchair skills training, behavioral counseling techniques, goal setting and motivational strategies, and possible risks associated with PA among manual wheelchair users (eg, spasms, blood pressure changes, unsafe transfers).

The peer trainer will deliver the SPPAC program through voice or video calls (depending on participant preference) using a mobile phone. Video calls will be the preferred approach because face-to-face interactions may reinforce vicarious experiences (eg, the peer trainer may demonstrate how to accomplish a specific task using their wheelchair). However, preference for voice calls will be accommodated. Participants will be encouraged to visit a SPPAC private Facebook page that can be accessed through the mobile phone. The Facebook page will encourage interaction with peer trainers and other participants, creating a social network for sharing stories and pictures of PA participation, monitoring goal progression, and discussing successes and barriers. Cultivating online social networks has been shown to have a large effect on motivation for PA [33].

The initial SPPAC session will focus on rapport development and getting to know the participant. An exchange of dialog will include introductions, discussion of interests, likes and dislikes, benefits of PA, current activities performed, and PA goals and motives. The peer trainer will assist with defining PA goals for the following week and developing an action plan (eg, overcoming barriers, sources of social support [ie, SPPAC Facebook page], rewards). The peer trainer will keep a log of PA goals and action plans for each participant, and participants will also be encouraged to monitor their own goal progression (eg, writing goals and action plans). Goal setting will follow the SMART goal framework [42].

The remainder of the sessions will follow a standardized format of (1) 30-minute calls to review the previous week (ie, what worked/did not work, identify challenges and how they were overcome/not overcome, review/add PA goals), (2) integration of motivational strategies (eg, provide choices to modify the program to suit their individual preferences [13], brainstorm ways of making activities more enjoyable), and (3) develop action and coping plans [11,12] for the next week. The final session will follow the same format, but will also include a summary and evaluation of the SPPAC, discussion of short- and long-term goals, and relapse prevention strategies (eg, remaining part of the private SPPAC Facebook group). All sessions will be guided by a SPPAC implementation checklist, which the peer trainer will complete during each session. Figure 3 presents an illustration depicting how the components of the SPPAC intervention map onto constructs of self-determination and social cognitive theories to influence motivation and behavior change.

Figure 3. Illustration of how the components of the SPPAC intervention map onto constructs of self-determination and social cognitive theories to influence motivation and behavior change. Figure adapted from Fortier et al [18].



Control Group

As suggested for comparisons between experimental and control groups in pilot studies, a pragmatic research approach will be applied to determine if SPPAC is better than usual care for increasing PA [43,44]. Usual care is defined as freely available PA resources that can be accessed by everyone with no special permissions. Therefore, for minimally structuring and standardizing the control group intervention, participants will receive only a handout with existing PA guidelines and a toolkit with recommendations for PA [35]. They will not be given any instruction in how to use the information, but they will not be restricted from the uptake of PA on their own volition.

Equipment

All participants (experimental and control group) will receive existing PA guidelines and a toolkit with recommendations for PA [35]. Participants in the experimental group will also receive a mobile phone (with a phone number, data plan, and preloaded Facebook apps). Participants may choose to use their personal mobile phone for the study if desired, but will have to download the video calling and Facebook apps and use their own data plan. On provision of the mobile phone, the tester will give instructions in how to use it. In addition, the participant manual will include step-by-step instructions in how to use the mobile phone.

Safety

Participating in PA carries innate risks. However, the SPPAC intervention is designed to minimize risks specifically for

manual wheelchair users, such as choosing appropriate activities for diagnosis, and selecting appropriate intensity and duration to minimize risk of injury. The SPPAC program incorporates strategies for safe participation, recognizing potentially unsafe situations, and seeking assistance when applicable. Participants will be asked to contact the research coordinator immediately if they experience unusual discomfort or pain. A Data and Safety Monitoring Board (statistician, researcher, health care professional, and manual wheelchair user external to the research team) will meet two times per year during the study to advise regarding safety issues [45].

Data Collection

All outcome measures are available in English and French. Descriptive characteristics, including age, sex, marital status, education, diagnoses (ie, disability and other diseases that could contraindicate PA participation), and previous manual wheelchair experience (ie, years using a manual wheelchair, where manual wheelchair is used, hours used per day, previous wheelchair skills training received) will be collected in person at baseline by a trained RA. Potentially confounding variables, such as psychological well-being (eg, depression, anxiety) and social support, will also be collected at baseline. Depression is inversely associated with PA participation [46,47] and influences PA for manual wheelchair users [48]. The Hospital Anxiety and Depression Score (HADS), a 14-item (two 7-item subscales) self-report scale, will be used to assess depression and anxiety [49,50]. Social support is also associated with PA participation and well-being [51,52] and will be assessed using the validated 6-item Interpersonal Support Evaluation List (ISEL) [53,54].

Primary Outcome Measure

The primary outcome measure, PA, will be measured objectively using actigraphy with a small and lightweight accelerometry-based activity monitor (ActiGraph 3GTX) worn on the body or manual wheelchair that does not impede participation in PA [55,56]. Three-dimensional data are stored in the monitor as "activity counts" [57]. Time between sampling units (epochs) will be set at 15 seconds, allowing the greatest sensitivity for low-intensity activity [58]. In previous studies of manual wheelchair users, concurrent validity was established [58] and instrument reliability of six monitors was high (r^2=.96, P<.001) [2].

After completion of all outcome measures at each time point, the RA will provide participants with two actigraphs (one will be positioned on the rear wheel of the manual wheelchair in a waterproof enclosure, the other will be worn on the nondominant arm). Participants will be asked to wear the Actigraph at all times over a 7-day period, except during sleep, bathing/showering, or swimming. Only data from the days in which participants wear the activity monitors for at least 13 hours per day will be included in the analyses [59].

Secondary Outcome Measures

Secondary outcomes reflect the proposed theoretical impacts of the SPPAC intervention. Given the dearth of evidence for manual wheelchair users in the literature, there is substantial value in understanding the relationship between PA behavior and the following variables to understand the mechanism of behavior change and to discerning a clinically important impact of the SPPAC program.

The 7-day Leisure-Time PA Questionnaire (LTPAQ) will assess self-reported PA [60]. Participants are asked to recall the frequency (number of bouts) and duration (minutes per bout) of light, moderate, and heavy intensity PA over the past 7 days. Acceptable test-retest reliability and construct validity are documented among manual wheelchair users with spinal cord injury [36,60]. Amount of PA is treated as an ordinal variable (ie, none, low, moderate, high).

The Wheelchair Skills Test-Questionnaire (WST-Q, version 4.2) will be used to assess perceived wheelchair skills capacity and performance [61]. The WST-Q is a structured assessment of 32 discrete mobility skills. WST-Q capacity is scored using a 3-point scale (0=fail; 1=pass with difficulty; 2=pass), with a maximum score of 64. A capacity score is calculated (0%-100%) reflecting the number of skills safely passed. WST-Q performance assesses how often each skill is performed on a 3-point scale (0=never; 1=sometimes; 2=always) and a performance score is calculated (0%-100%). Psychometric properties are documented for manual wheelchair users [62,63].

The Behavioral Regulation in Exercise Questionnaire 2 (BREQ-2) Revised will be used to evaluate PA motivation [64]. Four subscales measure varying degrees of exercise (or PA) regulation: external (eg, "I take part in PA because my family says I should"), introjected (eg, "I feel guilty when I do not participate in PA"), identified (eg, "It's important to me to be physically active"), and intrinsic (eg, "I take part in PA because it is fun") regulations. An additional subscale assesses amotivation (eg, "I think PA is a waste of time"). Each subscale contains four items except introjected regulation, which contains three items. Following the statement, "Why do you take part in PA?" participants are asked to respond to each item on a five-point Likert-type scale, ranging from 0=not at all true for me to 4=very true for me. Measurement properties of the BREQ-2 are documented [65].

The Leisure-Time PA Barrier Self-Efficacy Scale (LTPA BSE) will be used to assess self-efficacy to overcome salient barriers to PA participation (eg, when faced with transportation problems) [63]. Each of the six items is preceded with the following statement: "Assuming you were very motivated, how confident are you that you will participate in moderate to heavy leisure-time PA for at least 30 minutes on 3 days per week over the next 4 weeks even if..." Participants will be asked to rate their self-efficacy to overcome each barrier on a scale ranging from 0 to 100 (0=not confident; 50=moderately confident; and 100=completely confident). A mean score is calculated across the six items. The leisure-time PA barrier scale is reliable and valid [60,66].

The Wheelchair Use Confidence Scale-Short Form (WheelCon-SF) will be used to evaluate manual wheelchair use self-efficacy [67]. This 21-item self-report questionnaire reflects one's current confidence using a manual wheelchair to perform various activities in varying contexts and environments. Each item is rated on a scale from 0=not confident to 10=completely confident, and a score from 0%-100% is calculated. The

WheelCon-SF was derived from the original 65-item version, which has documented psychometric properties [68].

The Psychological Need Satisfaction in Exercise (PNSE) Scale will be used to assess the satisfaction of the psychological needs for PA [69]. Participants score 18 items that reflect how he/she might feel when they are physically active on a six-point Likert scale ranging from 1 (false) to 6 (true). A mean score is calculated for autonomy (6 items; "I feel free to exercise in my own way"), competence (6 items; "I feel that I am able to complete exercises that are personally challenging"), and relatedness (6 items; "I feel close to my exercise companions who appreciate how difficult exercise can be").

The Wheelchair Outcome Measure (WhOM) will be used to assess satisfaction with participation [70]. The WhOM, a client-specific semistructured interview, allows participants to select participation goals that reflect desired outcomes of the intervention. Participants rate the "importance" of the goal (0-10) and their current "satisfaction" with performance of this activity (0-10). Goals are then integrated into the intervention. The WhOM scoring is calculated by multiplying the "importance" by "satisfaction." Measurement properties of the WhOM have been documented [70].

Tertiary Outcomes

Tertiary outcomes will evaluate the implementation of the SPPAC program and ensure the SPPAC is delivered as intended. First, the peer trainer will complete a SPPAC checklist for each session, including questions about the logistics of the intervention (eg, time to complete each session, method of contact used) and a list of SPPAC components (eg, goal setting, rewards, skills training). Second, participants in the experimental group will complete a post-SPPAC questionnaire, which asks about attitude about PA, satisfaction with PA, perceived benefits and drawbacks, impact of SPPAC on PA, and changes in views of PA throughout the SPPAC intervention. Third, participants' reported satisfaction with SPPAC will be collected with the Health Care Climate Questionnaire (HCCQ) [71]. Participants will be asked six questions about their perceived need support from their peer trainer (eg, "My peer trainer listened to how I would like to do things regarding my PA" and "I felt my peer trainer provided me with choices and options about PA") on a 7-point Likert scale ranging from 1=strongly disagree to 7=strongly agree. High Cronbach alpha levels have been demonstrated [72,73].

Statistical Analyses

All data analyses are conducted with SPSS version 23. Multiple imputations are used to treat missing data [74]. Data are screened for statistical outliers and assumptions for each statistical test are examined [75].

Primary Outcomes

Actigraphy data will be imported into Microsoft Excel in the form of activity counts, then cleaned and entered into SPSS for analysis. A mixed-model ANCOVA will be conducted, controlling for the covariates. Summary statistics (mean, SD), effect size (Cohen *d*), and significance testing (*P*) with 95% confidence intervals will be estimated.

Secondary Outcomes

Mixed-model ANCOVA will also be used for significance testing and effect size calculations for all secondary outcome measures. Exploratory analyses will be conducted to investigate the strength and direction of the relationships between the primary and secondary outcomes, looking for moderate-to-strong relationships [76]. If the intervention has a moderate effect on the secondary outcomes and if the secondary outcomes have moderate-to-strong relationships with primary outcome (PA), a potential mediation (exploratory) is suggested.

Tertiary Outcomes

Descriptive and content analysis will be used to appraise SPPAC program implementation.

Results

This project is funded by the Craig H Neilsen Foundation and the Canadian Disability Participation Project. Proposals for additional project funds have been submitted to the Canadian Institute for Health Research (September 2016) and Fonds de Recherche du Santé Québec (December 2016). Two peer trainers have been recruited and trained and pilot evaluation of intervention implementation is currently underway. It is anticipated that enrollment for the proposed study will begin early in 2018, with final results by 2020.

Discussion

Given the compelling evidence linking PA and quality of life, and the low rates of PA participation among manual wheelchair users, there is a clear need to find strategies to promote PA. On developing a theory-based PA program using the MRC framework, a pilot RCT is a prudent next step [41]. Establishing first effect size estimates for primary and secondary outcomes through a pilot RCT may provide justification for a subsequent efficacy RCT and variability data for future sample size calculations.

The best method to deliver PA interventions for manual wheelchair users is largely unknown. Although community-based telephone-delivered [10,11] and peer-delivered interventions [12] have shown preliminary success in manual wheelchair users, larger studies comparing modalities among this target population are required to determine how to best promote PA. The use of online social media also represents an effective solution for motivating adults without disabilities to participate in PA [33], but the influence of online social support for manual wheelchair users has yet to be evaluated. Grounded in theory, the SPPAC program of research will provide further insight about how peers, telephones, and social media can influence PA uptake and maintenance.

Behavior change is a complex and multifaceted phenomenon with multiple influencing factors. Therefore, successfully changing behavior over the long term requires multilevel interventions that consider individuals within their physical and social environments [77]. Application of two cognitive-based theories (ie, self-determination and social cognitive theories)

posits that fulfilling the basic psychological needs (ie, autonomy, relatedness, and perceived control) drives behavior and that self-efficacy (synonymous to perceived control) is a strong and consistent predicator of behavior [15,16]. Therefore, cultivating an autonomy-supportive environment that enhances basic psychological needs, self-efficacy, and motivation through peer support provides a strong theoretical rationale that can effectively increase PA [18,12]. Evidence supports peer-led interventions that are grounded in social cognitive theory, both for improving PA in clinical and nonclinical populations [28] and for improving mobility outcomes for manual wheelchair users [31].

Gathering data on the important theoretical variables that are embedded within the SPPAC program will allow for exploration into mediating influences of complex psychological variables that will further our understanding about best strategies for changing PA behaviors in manual wheelchair users. The authors acknowledge the potential burden of the number of self-reported outcomes and the need for two meetings to collect objective PA data. However, it is anticipated that the self-reported outcomes can be completed in approximately 1 hour, and the tester will travel to obtain the Actigraph from the participants (or provide them with a postage-paid envelope for return to the research center) to reduce burden on participants. Future intervention studies can then integrate the most important behavior change determinants to best individualize PA programs for manual wheelchair users.

In addition to psychosocial factors, intervention dose and content represent important variables that need to be considered when promoting PA uptake and maintenance [78]. The Get in Motion program recommended up to 14 sessions of PA counseling over a 6-month period [11]. However, when asked about preferences for the SPPAC program, participants of focus groups (ie, manual wheelchair users, clinicians, and staff of community-based organizations) preferred that the SPPAC program consist of more contacts within a shorter timeframe [34]. The SPPAC program was designed accordingly [34]. In terms of optimal timing for promoting PA, a recent study among individuals with spinal cord injury suggested that the first 2 months are the most critical for successfully promoting PA [78]. However, a recent peer-led manual wheelchair training intervention showed increased participation in meaningful activities among manual wheelchair users up to 25 years after obtaining a manual wheelchair [31].

Beyond attaining knowledge of important behavioral factors influencing PA uptake and maintenance, the potential benefits of SPPAC include decreased environmental (eg, accessible facilities, transportation) and social barriers (eg, perceived stigma) to PA, limited burden on health care professionals, development of online social supports, and potential cost savings. Moreover, SPPAC has potential for application across age and diagnostic groups, a widespread geographic reach, and allows for a large trainer-to-participant ratio, all which may have time and cost efficiencies in program delivery. Future RCTs may evaluate some of the projected benefits of the SPPAC program.

Foreseen limitations of this study include the heterogeneity of the sample with regard to diagnoses. It is possible that diagnoses (as well as other sociodemographic factors, such as age) may influence the study outcomes. However, the purpose of this pilot study is to provide proof of concept of a novel intervention that may be adopted by manual wheelchair users in general. Future studies may examine diagnoses-specific interventions or consider stratification for various demographic variables. There is also a risk that participants (in both groups) may inadvertently discuss the study with other participants (eg, if they obtain health care services from the same clinic, if they are friends on Facebook) or with testers. Because the intervention is administered by phone on an individual basis, the study itself will not evoke a common meeting place for participants. Moreover, recruitment will target manual wheelchair users in remote geographic locations who may otherwise not have access to community-based programs. To reduce the risk of contamination, peer trainers will remind the participants during each session not to discuss the study with anyone outside of the intervention (including peers/friends or testers).

The SPPAC intervention aims to empower manual wheelchair users to manage their own health through implementation of autonomous supportive environments that also enhance self-efficacy through the use of a peer trainer and mobile phone technology. To our knowledge, no study has evaluated the combined potential of a mobile phone-delivered and peer-led PA intervention for manual wheelchair users. Such an approach may overcome many of the barriers to PA participation within this population, while incorporating important theoretical variables that are associated with behavior change. The SPPAC program has the potential to reach a large number of manual wheelchair users, thus may play an important role in addressing PA behavior change that could have a profound impact on health and health economics.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Peer-review reports.

[PDF File (Adobe PDF File), 604KB - resprot_v6i4e69_app1.pdf]

References

1. Sweet SN, Martin GK, Tomasone JR. Investigating intermediary variables in the physical activity and quality of life relationship in persons with spinal cord injury. Health Psychol 2013 Aug;32(8):877-885. [doi: 10.1037/a0032383] [Medline: 23566180]
2. Warms CA, Whitney JD, Belza B. Measurement and description of physical activity in adult manual wheelchair users. Disabil Health J 2008 Oct;1(4):236-244 [FREE Full text] [doi: 10.1016/j.dhjo.2008.07.002] [Medline: 21122734]
3. Best KL, Miller WC. Physical and leisure activity in older community-dwelling Canadians who use wheelchairs: a population study. J Aging Res 2011 Apr 13;2011:147929 [FREE Full text] [doi: 10.4061/2011/147929] [Medline: 21584226]
4. Rimmer JH. Use of the ICF in identifying factors that impact participation in physical activity/rehabilitation among people with disabilities. Disabil Rehabil 2006 Sep 15;28(17):1087-1095. [doi: 10.1080/09638280500493860] [Medline: 16950739]
5. Anderson LS, Heyne LA. Physical activity for children and adults with disabilities: an issue of “amplified” importance. Disabil Health J 2010 Apr;3(2):71-73. [doi: 10.1016/j.dhjo.2009.11.004] [Medline: 21122770]
6. Tomasone JR, Wesch NN, Martin Ginis KA, Noreau L. Spinal cord injury, physical activity, and quality of life: a systematic review. Kinesiol Rev 2013;2(2):113-129.
7. Durstine JL, Painter P, Franklin BA, Morgan D, Pitetti KH, Roberts SO. Physical activity for the chronically ill and disabled. Sports Med 2000 Sep;30(3):207-219. [Medline: 10999424]
8. Kosma M, Cardinal BJ, McCubbin JA. Recruitment techniques among understudied populations and their implications for physical activity promotion. Quest 2004 Nov;56(4):413-420. [doi: 10.1080/00336297.2004.10491834]
9. Cardenas D, Yilmaz B. Recruitment of spinal cord injury patients to clinical trials: challenges and solutions. Top Spinal Cord Injury Rehabil 2006 Jan;11(3):12-23. [doi: 10.1310/FAEH-YGYJ-Q4LF-0X6W]
10. Froehlich-Grobe K, Lee J, Aaronson L, Nary DE, Washburn RA, Little TD. Exercise for everyone: a randomized controlled trial of project workout on wheels in promoting exercise among wheelchair users. Arch Phys Med Rehabil 2014 Jan;95(1):20-28 [FREE Full text] [doi: 10.1016/j.apmr.2013.07.006] [Medline: 23872080]
11. Arbour-Nicitopoulos KP, Tomasone JR, Latimer-Cheung AE, Martin GK. Get in motion: an evaluation of the reach and effectiveness of a physical activity telephone counseling service for Canadians living with spinal cord injury. PM R 2014 Dec;6(12):1088-1096. [doi: 10.1016/j.pmrj.2014.05.018] [Medline: 24990447]
12. Latimer-Cheung AE, Arbour-Nicitopoulos KP, Brawley LR, Gray C, Justine WA, Prapavessis H, et al. Developing physical activity interventions for adults with spinal cord injury. Part 2: motivational counseling and peer-mediated interventions for people intending to be active. Rehabil Psychol 2013 Aug;58(3):307-315. [doi: 10.1037/a0032816] [Medline: 23978086]
13. Wilson PM, Rodgers WM, Blanchard CM, Gessell J. The relationship between psychological needs, self-determined motivation, exercise attitudes, and physical fitness. J Appl Social Pyschol 2003 Nov;33(11):2373-2392. [doi: 10.1111/j.1559-1816.2003.tb01890.x]
14. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol 2000 Jan;55(1):68-78. [Medline: 11392867]
15. Deci EL, Ryan RM. The “what” and “why” of goal pursuits: human needs and the self-determination of behavior. Psychol Inq 2000;11(4):227-268.
16. Bandura A. Self-Efficacy: The Exercise of Control. New York: WH Freeman; 1997.
17. Ryan RM, Patrick H, Deci EL, Williams GC. Facilitating health behaviour change and its maintenance: interventions based on Self-Determination Theory. European Health Psychol 2008;10:2-5.
18. Fortier MS, Hogg W, O'Sullivan TL, Blanchard C, Reid RD, Sigal RJ, et al. The physical activity counselling (PAC) randomized controlled trial: rationale, methods, and interventions. Appl Physiol Nutr Metab 2007 Dec;32(6):1170-1185. [doi: 10.1139/H07-075] [Medline: 18059592]
19. Neupert SD, Lachman ME, Whitbourne SB. Exercise self-efficacy and control beliefs: effects on exercise behavior after an exercise intervention for older adults. J Aging Phys Act 2009 Jan;17(1):1-16 [FREE Full text] [Medline: 19299835]
20. McAuley E, Szabo A, Gothe N, Olson EA. Self-efficacy: implications for physical activity, function, and functional limitations in older adults. Am J Lifestyle Med 2011 Jul;5(4):361-369 [FREE Full text] [doi: 10.1177/1559827610392704] [Medline: 24353482]
21. Rodgers WM, Markland D, Selzler A, Murray TC, Wilson PM. Distinguishing perceived competence and self-efficacy: an example from exercise. Res Q Exerc Sport 2014 Nov 20;85(4):527-539. [doi: 10.1080/02701367.2014.961050]

22. Ashford S, Edmunds J, French DP. What is the best way to change self-efficacy to promote lifestyle and recreational physical activity? A systematic review with meta-analysis. Br J Health Psychol 2010 May;15(Pt 2):265-288. [doi: 10.1348/135910709X461752] [Medline: 19586583]
23. Medvene L. Self-help groups, peer helping, and social comparison. In: Spacapan S, Oskamp S, editors. Helping and Being Helped: Naturalistic Studies. Newbury Park, CA: Sage Publications; 1992:49-81.
24. Standal OF, Jespersen E. Peers as resources for learning: a situated learning approach to adapted physical activity in rehabilitation. Adapt Phys Act Quart 2008;25:208-227.
25. Veith E, Sherman J, Pellino T, Yasui N. Qualitative analysis of the peer-mentoring relationship among individuals with spinal cord injury. Rehab Psych 2006;51(4):289-298. [doi: 10.1037/0090-5550.51.4.289]
26. Houlihan BV, Everhart-Skeels S, Gutnick D, Pernigotti D, Zazula J, Brody M, et al. Empowering adults with chronic spinal cord injury to prevent secondary conditions. Arch Phys Med Rehabil 2016 Oct;97(10):1687-1695. [doi: 10.1016/j.apmr.2016.04.005] [Medline: 27143581]
27. Lorig K, Ritter P, Stewart A, Sobel DS, Brown BW, Bandura A, et al. Chronic disease self-management program: 2-year health status and health care utilization outcomes. Med Care 2001 Nov;39(11):1217-1223. [Medline: 11606875]
28. Best KL, Miller WC, Eng JJ, Routhier F. Systematic review and meta-analysis of peer-led self-management programs for increasing physical activity. Int J Behav Med 2016 Oct;23(5):527-538. [doi: 10.1007/s12529-016-9540-4] [Medline: 26846476]
29. Ginis KA, Nigg CR, Smith AL. Peer-delivered physical activity interventions: an overlooked opportunity for physical activity promotion. Transl Behav Med 2013 Dec;3(4):434-443 [FREE Full text] [doi: 10.1007/s13142-013-0215-2] [Medline: 24294332]
30. Webel AR, Okonsky J, Trompeta J, Holzemer WL. A systematic review of the effectiveness of peer-based interventions on health-related behaviors in adults. Am J Public Health 2010 Feb;100(2):247-253 [FREE Full text] [doi: 10.2105/AJPH.2008.149419] [Medline: 20019321]
31. Best KL, Miller WC, Huston G, Routhier F, Eng JJ. Pilot study of a peer-led wheelchair training program to improve self-efficacy using a manual wheelchair: a randomized controlled trial. Arch Phys Med Rehabil 2016 Jan;97(1):37-44. [doi: 10.1016/j.apmr.2015.08.425] [Medline: 26343171]
32. Maher CA, Lewis LK, Ferrar K, Marshall S, De Bourdeaudhuij I, Vandelanotte C. Are health behavior change interventions that use online social networks effective? A systematic review. J Med Internet Res 2014;16(2):e40 [FREE Full text] [doi: 10.2196/jmir.2952] [Medline: 24550083]
33. Jingwen Z, Devon B, Sijia Y, Damon C. Efficacy and causal mechanism of an online social media intervention to increase physical activity: results of a randomized controlled trial. Prev Med Rep 2015;2:651.
34. Best KL, Routhier F, Sweet SN, Arbour-Nicitopoulos KP, Borisoff JF, Noreau L, et al. Development of a smartphone-delivered peer physical activity counselling program for manual wheelchair users: a mixed-methods approach. Arch Phys Med Rehab 2016 Oct;97(10):e48. [doi: 10.1016/j.apmr.2016.08.143]
35. Ginis KA, Hicks AL, Latimer AE, Warburton DE, Bourne C, Ditor DS, et al. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. Spinal Cord 2011 Nov;49(11):1088-1096. [doi: 10.1038/sc.2011.63] [Medline: 21647164]
36. Best KL, Miller WC, Routhier F, Eng JJ, Goldsmith C. Feasibility of the Wheelchair Self-Efficacy Enhanced for Use (WheelSeeU) training program: study protocol for a randomized controlled trial. Can J Occu Ther 2014;81(5):308-319.
37. Jamnik VK, Warburton DE, Makarski J, McKenzie DC, Shephard RJ, Stone JA, et al. Enhancing the effectiveness of clearance for physical activity participation: background and overall process. Appl Physiol Nutr Metab 2011 Jul;36 Suppl 1:S3-S13 [FREE Full text] [doi: 10.1139/h11-044] [Medline: 21800946]
38. Warburton DE, Jamnik VK, Bredin SS, Gledhill N. The 2014 Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health Fit J Canada 2014;7(1):80-83.
39. Nooijen CF, Stam HJ, Bergen MP, Bongers-Janssen HM, Valent L, van Langeveld S, Act-Active Research Group, et al. A behavioural intervention increases physical activity in people with subacute spinal cord injury: a randomised trial. J Physiother 2016 Jan;62(1):35-41 [FREE Full text] [doi: 10.1016/j.jphys.2015.11.003] [Medline: 26701155]
40. Faul F, Erdfelder E, Lang A, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007 May;39(2):175-191. [Medline: 17695343]
41. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M, Medical Research Council Guidance. Developing and evaluating complex interventions: the new Medical Research Council guidance. BMJ 2008;337:a1655 [FREE Full text] [Medline: 18824488]
42. Scobbie L, Wyke S, Dixon D. Identifying and applying psychological theory to setting and achieving rehabilitation goals. Clin Rehabil 2009 Apr;23(4):321-333. [doi: 10.1177/0269215509102981] [Medline: 19293291]
43. Thorpe KE, Zwarenstein M, Oxman AD, Treweek S, Furberg CD, Altman DG, et al. A pragmatic-explanatory continuum indicator summary (PRECIS): a tool to help trial designers. J Clin Epidemiol 2009 May;62(5):464-475. [doi: 10.1016/j.jclinepi.2008.12.011] [Medline: 19348971]

44. Czajkowski SM, Powell LH, Adler N, Naar-King S, Reynolds KD, Hunter CM, et al. From ideas to efficacy: the ORBIT model for developing behavioral treatments for chronic diseases. Health Psychol 2015 Oct;34(10):971-982 [FREE Full text] [doi: 10.1037/hea0000161] [Medline: 25642841]
45. DeMets D. Data and safety monitoring boards. In: Armitage P, Colton T, editors. Encyclopedia of Biostatistics. Chichester: John Wiley & Sons; 1998:1066-1071.
46. Tawashy AE, Eng JJ, Lin KH, Tang PF, Hung C. Physical activity is related to lower levels of pain, fatigue and depression in individuals with spinal-cord injury: a correlational study. Spinal Cord 2009 Apr;47(4):301-306 [FREE Full text] [doi: 10.1038/sc.2008.120] [Medline: 18936771]
47. Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SS. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. Int J Behav Nutr Phys Act 2010 May 11;7:39 [FREE Full text] [doi: 10.1186/1479-5868-7-39] [Medline: 20459783]
48. Ginis KA, Latimer AE, McKechnie K, Ditor DS, McCartney N, Hicks AL, et al. Using exercise to enhance subjective well-being among people with spinal cord injury: The mediating influences of stress and pain. Rehabil Psychol 2003;48(3):157-164. [doi: 10.1037/0090-5550.48.3.157]
49. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983 Jun;67(6):361-370. [Medline: 6880820]
50. Bjelland I, Dahl AA, Haug TT, Neckelmann D. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. J Psychosom Res 2002 Feb;52(2):69-77. [Medline: 11832252]
51. Yu G, Renton A, Schmidt E, Tobi P, Bertotti M, Watts P, et al. A multilevel analysis of the association between social networks and support on leisure time physical activity: evidence from 40 disadvantaged areas in London. Health Place 2011 Sep;17(5):1023-1029 [FREE Full text] [doi: 10.1016/j.healthplace.2011.07.002] [Medline: 21784693]
52. Heitzmann CA, Kaplan RM. Assessment of methods for measuring social support. Health Psychol 1988;7(1):75-109. [Medline: 3277843]
53. Cohen S, Hoberman HM. Positive events and social supports as buffers of life change stress. J Appl Social Pyschol 1983 Apr;13(2):99-125. [doi: 10.1111/j.1559-1816.1983.tb02325.x]
54. Cohen S, Mermelstein R, Kamarck T, Hoberman HM. Measuring the functional components of social support. In: Sarason IG, editor. Social Support: Theory, Research & Applications (NATO ASI Series). Dordrecht, Netherlands: Martinus Nijhoff Publishers; 1985:73-94.
55. Nightingale TE, Walhim J, Thompson D, Bilzon JL. Predicting physical activity energy expenditure in manual wheelchair users. Med Sci Sports Exerc 2014 Sep;46(9):1849-1858. [doi: 10.1249/MSS.0000000000000291] [Medline: 25134004]
56. García-Massó X, Serra-Añó P, García-Raffi LM, Sánchez-Pérez EA, López-Pascual J, Gonzalez LM. Validation of the use of Actigraph GT3X accelerometers to estimate energy expenditure in full time manual wheelchair users with spinal cord injury. Spinal Cord 2013 Dec;51(12):898-903. [doi: 10.1038/sc.2013.85] [Medline: 23999111]
57. Warms CA, Belza BL. Actigraphy as a measure of physical activity for wheelchair users with spinal cord injury. Nurs Res 2004;53(2):136-143. [Medline: 15084999]
58. Herrmann SD, Hart TL, Lee CD, Ainsworth BE. Evaluation of the MyWellness Key accelerometer. Br J Sports Med 2011 Feb;45(2):109-113. [doi: 10.1136/bjsm.2009.062182] [Medline: 19736173]
59. Martin KA, Latimer AE, Hanley H, Watson K, Hicks AL, McCartney N, et al. Sustaining exercise motivation and participation among people with spinal cord injury: lessons learned from a 9-month intervention. Palaestra 2002;18(1).
60. Phang SH, Ginis KM, Routhier F, Lemay V. The role of self-efficacy in the wheelchair skills-physical activity relationship among manual wheelchair users with spinal cord injury. Disabil Rehabil 2012;34(8):625-632. [doi: 10.3109/09638288.2011.613516] [Medline: 21981243]
61. Kirby RL, Dupuis DJ, Macphee AH, Coolen AL, Smith C, Best KL, et al. The wheelchair skills test (version 2.4): measurement properties. Arch Phys Med Rehabil 2004 May;85(5):794-804. [Medline: 15129405]
62. Hosseini SM, Oyster ML, Kirby RL, Harrington AL, Boninger ML. Manual wheelchair skills capacity predicts quality of life and community integration in persons with spinal cord injury. Arch Phys Med Rehabil 2012 Dec;93(12):2237-2243. [doi: 10.1016/j.apmr.2012.05.021] [Medline: 22684049]
63. Lemay V, Routhier F, Noreau L, Phang SH, Ginis KA. Relationships between wheelchair skills, wheelchair mobility and level of injury in individuals with spinal cord injury. Spinal Cord 2012 Jan;50(1):37-41. [doi: 10.1038/sc.2011.98] [Medline: 21931330]
64. Markland D, Tobin V. A modification to the Behavioural Regulation in Exercise Questionnaire to include an assessment of amotivation. J Sport Exer Psychol 2004;26(2):191-196.
65. Moustaka FC, Vlachopoulos SP, Vazou S, Kaperoni M, Markland DA. Initial validity evidence for the Behavioral Regulation in Exercise Questionnaire-2 among Greek exercise participants. Eur J Psychol Assess 2010 Jan;26(4):269-276. [doi: 10.1027/1015-5759/a000036]
66. Arbour-Nicitopoulos KP, Ginis KA, Latimer AE. Planning, leisure-time physical activity, and coping self-efficacy in persons with spinal cord injury: a randomized controlled trial. Arch Phys Med Rehabil 2009 Dec;90(12):2003-2011. [doi: 10.1016/j.apmr.2009.06.019] [Medline: 19969161]

67. Sakakibara BM, Miller WC, Rushton PW. Rasch analyses of the wheelchair use confidence scale. Arch Phys Med Rehabil 2015 Jun;96(6):1036-1044 [FREE Full text] [doi: 10.1016/j.apmr.2014.11.005] [Medline: 25461823]
68. Rushton PW, Miller WC, Lee KR, Eng JJ, Yip J. Development and content validation of the Wheelchair Use Confidence Scale: a mixed-methods study. Disabil Rehabil Assist Technol 2011;6(1):57-66 [FREE Full text] [doi: 10.3109/17483107.2010.512970] [Medline: 20809874]
69. Wilson PM, Rogers WT, Rodgers WM, Wild TC. The Psychological Need Satisfaction in Exercise Scale. J Sport Exercise Psy 2006 Sep;28(3):231-251. [doi: 10.1123/jsep.28.3.231]
70. Miller WC, Garden J, Mortenson WB. Measurement properties of the wheelchair outcome measure in individuals with spinal cord injury. Spinal Cord 2011 Sep;49(9):995-1000. [doi: 10.1038/sc.2011.45] [Medline: 21577219]
71. Williams GC, Grow VM, Freedman ZR, Ryan RM, Deci EL. Motivational predictors of weight loss and weight-loss maintenance. J Pers Soc Psychol 1996 Jan;70(1):115-126. [Medline: 8558405]
72. Williams GC, McGregor HA, King D, Nelson CC, Glasgow RE. Variation in perceived competence, glycemic control, and patient satisfaction: relationship to autonomy support from physicians. Patient Educ Couns 2005 Apr;57(1):39-45. [doi: 10.1016/j.pec.2004.04.001] [Medline: 15797151]
73. Williams GC, McGregor HA, Zeldman A, Freedman ZR, Deci EL. Testing a self-determination theory process model for promoting glycemic control through diabetes self-management. Health Psychol 2004 Jan;23(1):58-66. [doi: 10.1037/0278-6133.23.1.58] [Medline: 14756604]
74. Schlomer GL, Bauman S, Card NA. Best practices for missing data management in counseling psychology. J Couns Psychol 2010 Jan;57(1):1-10. [doi: 10.1037/a0018082] [Medline: 21133556]
75. Tabachnick BG, Fidell LS. Using Multivariate Statistics. 5th edition. Boston, MA: Pearson Education; 2007.
76. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd Edition. Hillside, NJ: Lawrence Erlbaum Associates; 1988.
77. Sallis J, Owen N, Fisher E. Ecological models of health behavior. In: Glanz K, Rimer BK, Viswanath K, editors. Health Behavior Health Education: Theory, Research and Practice. 4th Edition. San Francisco, CA: Jossey-Bass; 2008:465-485.
78. Tomasone JR, Arbour-Nicitopoulos KP, Latimer-Cheung AE, Ginis AK. The relationship between the implementation and effectiveness of a nationwide physical activity telephone counseling service for adults with spinal cord injury. Disabil Rehabil 2016 Dec 28:1-11. [doi: 10.1080/09638288.2016.1261415] [Medline: 28029067]

Abbreviations

BREQ-2: Behavioral Regulation in Exercise Questionnaire 2
ePARmed-X+PA: electronic Physical Activity Readiness Medical Examination
HADS: Hospital Anxiety and Depression Score
HCCQ: Health Care Climate Questionnaire
IRDPQ: Institut de réadaptation en déficience physique de Québec
IRGLM: Institut de réadaptation Gingras-Lindsay-de-Montréal
ISEL: Interpersonal Support Evaluation List
JRH: Jewish Rehabilitation Hospital
MRC: Medical Research Council
PA: physical activity
PAR-Q+PA: Readiness Questionnaire for Everyone
PNSES: Psychological Need Satisfaction in Exercise Scale
RA: research assistant
RCT: randomized controlled trial
SPPAC: Smartphone Peer Physical Activity Counseling
WheelCon-SF: Wheelchair Use Confidence Scale-Short Form
WhOM: Wheelchair Outcome Measure
WST-Q: Wheelchair Skills Test-Questionnaire

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Original Paper

Managing Depressive Symptoms in the Workplace Using a Web-Based Self-Care Tool: A Pilot Randomized Controlled Trial

Abigail Hirsch[1*], PhD; Jason Luellen[2*], PhD; Jared M Holder[2*], MA; Gregory Steinberg[*], MB, BCh; Teresa Dubiel[1*], RN, BSN; Anna Blazejowskyj[1*], BS; Krista Schladweiler[1*], PhD

[1]myStrength, Inc, Denver, CO, United States

[2]Centerstone of America, Nashville, TN, United States

[*]all authors contributed equally

Corresponding Author:
Krista Schladweiler, PhD
myStrength, Inc
1875 Lawrence Street
Suite 550
Denver, CO,
United States
Phone: 1 302 983 2954
Fax: 1 720 452 2980
Email: kschladweiler@mystrength.com

Abstract

Background: Depression in the workplace creates a significant burden on employees and employers in terms of lost productivity and related costs. myStrength provides a robust, holistic Web- and mobile-based solution empowering users to learn, practice, and implement a range of evidence-based psychological interventions.

Objective: The main aim of this study was to demonstrate improvement in depressive symptoms among employees at risk of depression through myStrength use.

Methods: A 26-week, parallel-arm, pilot, randomized controlled trial was designed to assess the effectiveness of myStrength compared to a series of informational "Depression Tip/Fact of the Week" emails as the active control arm. Study participants (n=146) were commercially insured employees of a mid-sized financial software solutions firm. The primary outcome was self-reported change in depression score as best fit by a linear random effects model accounting for individual baseline symptoms.

Results: The final sample consisted of 78 participants in the experimental arm, myStrength, and 68 participants in the active control arm. myStrength users demonstrated significantly steeper and more rapid reduction in depressive symptoms over time compared to the active control (P<.001), suggesting that the intervention generated improvement in behavioral health symptoms, even in a nonclinical sample.

Conclusions: This pilot study builds foundational support for the scalable deployment of myStrength as a complementary behavioral health offering to promote overall mental health and well-being in the workplace.

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KEYWORDS

depression; behavioral health; health promotion; workplace; randomized controlled trial

Introduction

Identifying tools to manage both clinical and subclinical depression in an effective and broad-reaching manner could have widespread benefits. Depression is one of the most common and debilitating disorders in the United States [1]. In 2014, 6.7% of American adults aged 18 years or older (15.7 million people) had at least one major depressive episode [2]. Such episodes can result in significant impairments in home life, work function, and social relationships.

Depression in the workplace poses a significant burden to both employees and employers. A nationally representative, epidemiologic survey found that 6.4% of employees in the workplace had depression; of those, 13.8% were classified mild, 38.5% moderate, and 47.7% as severe [3,4]. Depression is also a major cost driver for employers [5,6]. Depression annually

costs US businesses over $51 billion in absenteeism from work and lost productivity on top of the $26 billion in direct treatment costs [7].

US employers looking for ways to manage the cost burden of depression in the workplace are increasingly turning to cutting-edge platforms to provide real-time access to care [8,9]. One way to bend the cost curve is to broaden the reach of preventative interventions to engage people both with clinical levels of depression and those demonstrating subthreshold depressive symptoms before symptoms and associated costs elevate [10-13].

One cost-effective way to provide such preventative care for depression is via Web-based interventions [14,15]. Computerized cognitive behavioral therapy (cCBT) for treating clinical depression has been well validated in efficacy trials [12,16]. Likewise, randomized controlled trials (RCTs) suggest that the positive impacts from online tools for people diagnosed with clinical depression also extend to those with milder symptoms [17,18]. Interestingly, a growing body of literature suggests that the greatest impact of cCBT is found among users who might not seek out or have access to other standard treatment options like talk therapy [19-21].

In developing an appropriate digital platform to be used for broad, cost-effective, employer-based outreach, scalability and low price point per user are paramount. At the same time, past research suggests that having a guided component to Internet interventions improves engagement and outcomes [22,23]. In an era where Web and mobile apps can be customized to the individual user, it is possible that such customization could help to increase engagement and impact without elevating program costs as with guided interventions.

myStrength, the Web and mobile self-care platform piloted in this study, is designed to close the behavioral health care treatment gap by extending access to empirically validated psychological interventions through a population-based approach [24]. myStrength builds on existing Web-based cCBT for clinical depression by incorporating wrap-around brief resources from mindfulness approaches, acceptance and commitment therapy, brief strategic therapies, and motivational interviewing while offering a unique set of programmatic recommendations to each user based on a profile process. The population health approach taken allows for the deployment and evaluation of psychological interventions in a real-world setting for employer-based depression management.

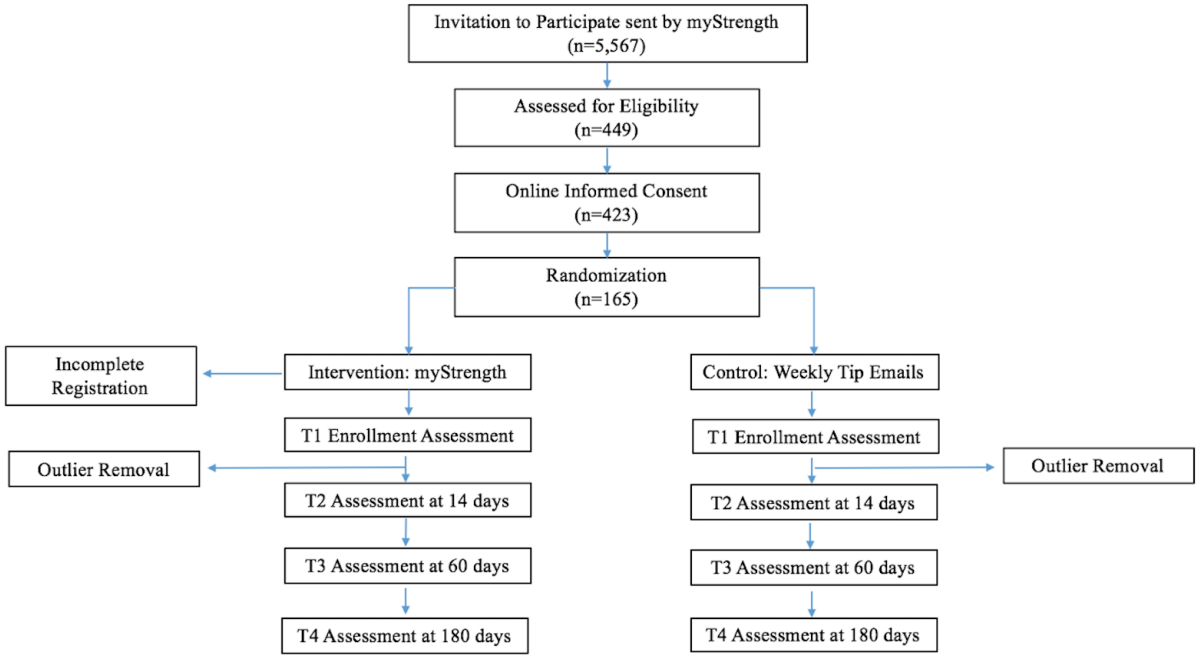
For the past 6 years, myStrength has been delivering evidence-based psychological interventions to users affiliated with over 100 mental health providers, ranging from large national health insurance providers to community mental health clinics. This pilot study is the first of its kind to rigorously evaluate the impact and effectiveness of myStrength in terms of depressive symptom burden reduction in a real-world setting.

Methods

Study Design

A 26-week, parallel-arm RCT with a single pretest and three posttests was piloted to examine the impact of myStrength use on self-reported depression symptom burden. This design was selected in accordance with the Pretest-Posttest Control Group Design with Multiple Substantive Posttests recommended by Shadish et al [25]. See the study flowchart in Figure 1, including an overview of the enrollment process and assessment timing.

Figure 1. Study flowchart.



Study Participants and Recruitment

Participants were recruited from the 5567 commercially insured employees of a financial software solutions company. The study was conducted in partnership with Aetna, the company's health benefits provider, and was open to all employees. Participants were excluded if they were under 18 years of age; were diagnosed with Alzheimer's disease, Parkinson's disease, dementia, delirium, or other cognitive impairment; had been institutionalized; or were diagnosed with obsessive-compulsive disorder because in each of these cases there were concerns raised by the sponsoring entity about the potential for adverse events in an unmonitored setting.

An executive recruitment email was sent out to all employees by the company's head of human resources inviting individuals to voluntarily participate in the pilot of new tools for managing mood and stress. Two follow-up recruitment emails were sent out, with 5 days between each email. Participants were told there were two arms of the study intended to improve mental health during informed consent: (1) an interactive website and (2) receipt of an email series.

Interested participants accessed an online enrollment screener and completed informed consent. On the first page of this screening, potential participants were asked if they met any of the exclusion criteria. Those who endorsed exclusion criteria were redirected to a general resources page and not permitted to continue registration for the study. Because each employee received a unique email link to the registration survey, this redirect also meant people could not return and alter their responses.

Intervention Group

The experimental arm was given access to myStrength resources include the following: cCBT modules for depression and anxiety, mindfulness and other empirically validated tools taught via short form video, substance use motivational interviewing and relapse prevention modules, a mood tracker, community and personal inspirations, motivational quotes, spiritual and faith-based resources if users elect to receive these, and a searchable library of over 1600 additional mental health and wellness resources if users elect to receive these, and a searchable library of over 1600 additional mental health and wellness resources. In addition, participants in the experimental arm received a series of 12 emails highlighting different aspects of myStrength and specific tools for managing depression, as well as reminders to access the platform. Participants could access any of the resources available on the myStrength website and mobile platform at their own pace and at any time during the 26-week study period. Multimedia Appendices 1 and 2 provide visual representations of the myStrength Web and mobile interface.

Active Control Group

The active control arm received 12 "Tip/Fact of the Week" emails with factual statements about mental health or depression during the 26-week study period. Emails were designed to contain accurate information pertaining to depression signs and symptoms without offering clinical suggestions or advice (for example, see Multimedia Appendix 3).

Outcome Measures

The primary outcome measure was the depression subscale score (range 0 to 42) of the Depression, Anxiety, and Stress Scale (DASS-21), a 21-item validated self-report questionnaire designed to measure symptom severity [26]. Participants in both the experimental and active control arms followed the same assessment schedule. Each participant completed an assessment at enrollment (T1) and were prompted by email reminders to be reassessed at 14, 60, and 180 days (T2-T4, respectively). Demographic information collected included gender, age, level of education, ethnicity, and mental health treatment status.

Randomization and Blinding

A randomized design was selected to prospectively assess the impact of myStrength use on the primary outcome, depression score over time. The online survey software, FluidSurveys, consented and randomly assigned study participants to either the intervention arm or active control. Per institutional review board (IRB) review and approval, study participants knew of their study arm assignment; however, they were unaware that the active control did not include platform access. Randomization occurred after prescreening for eligibility and informed consent and thus recruited a study population more open to help-seeking. The study employed a sampling ratio of 1.5:1 with no stratification and with the larger number of individuals assigned to the experimental arm. This approach was taken to sufficiently power the experimental arm, as those study participants engaged with myStrength were required to complete the extra step of accessing the website and completing registration for the program. The active control arm had no similar post-enrollment burden.

Statistical Analyses

Data analyses were conducted using R version 3.3.2 (The R Foundation). The primary outcome, depression score, was analyzed using mixed effects regression. A random-intercept was modeled to account for individual baseline variation. Predictors included study arm (group), a continuous measure of time (days since baseline; time), and the interaction of group and time (group × time). Covariates included gender, age group, and a baseline indicator of whether the participant was receiving treatment outside the study as measured by self-report at T1 (receiving treatment). In addition, each regression model adjusted for the corresponding baseline T1 outcome assessment (depression).

Ethics

All data collected were retained by the experimenters and no individual-level data were shared with Aetna Inc or the employer. Likewise, myStrength, the intervention offered in the experimental arm, stores all responses in a manner compliant with the Health Insurance Portability and Accountability Act.

This pilot study was not prospectively registered on Clinicaltrials.gov given the original intent to demonstrate feasibility. This research was reviewed and approved by Sterling IRB #4959.

Results

Participant Flow and Outlier Consideration

As depicted in Figure 1, the recruitment email was sent out to the census of 5567 employees. Among them, 449 (8.1%) completed the online enrollment screening, 26 (5.8%) of whom did not meet eligibility criteria and were excluded. The randomization sample comprised 165 screened individuals (39.0%) who met the eligibility criteria and signed informed consent to participate. Randomization resulted in 96 participants in the experimental arm (58.2%) and 69 participants in the active control arm (41.8%).

Of 96 experimental study participants, 12 (12.5%) failed to complete registration. Case review revealed their data to be particularly sparse with regard to outcomes and covariates. Only 3 of 12 had any outcome data available, typically a single response on the third occasion. For that reason, study participants who failed to complete registration were omitted from the primary analyses, and the effective sample size was reduced from 165 to 153. Acknowledging the *a priori* goal of analyzing the data by intention to treat, this pilot study was unable to impute the missing data due to sparseness.

Despite random assignment to study group, between-group differences on the DASS-21 depression score at baseline (T1) were identified and subsequently removed from all analyses. A total of 7 statistical outliers (6 in the experimental group and 1 in the active control group) were identified as 1.5 *I* beyond the upper or lower quartile, where *I* is the interquartile range. Descriptive statistics and regression models were conducted with and without the inclusion of outliers and the interpretation of findings was consistent.

To demonstrate the impact of outlier inclusion on the average depression score over time, a side-by-side comparison of the study population with and without the outliers identified at baseline is presented. Figure 2 shows the average depression score over time for both the experimental and active control arms with the 7 statistical outliers included. Figure 3 shows the average depression score over time for both the experimental and active control arms with the outliers removed. Clear separation in depression scores was observed between the experimental arm and active control at baseline; however, the experimental arm with the outliers included (n=84) is skewed in favor of more severe depressive symptom burden as compared to the trimmed experimental arm with the outliers removed (n=78). Given the intent of the pilot study to assess the feasibility of myStrength to favorably impact depressive symptoms in a relatively healthy employee population, the statistical outliers were removed from all further analyses.

Figure 2. Depression scores over time, stratified by group, with outliers included.

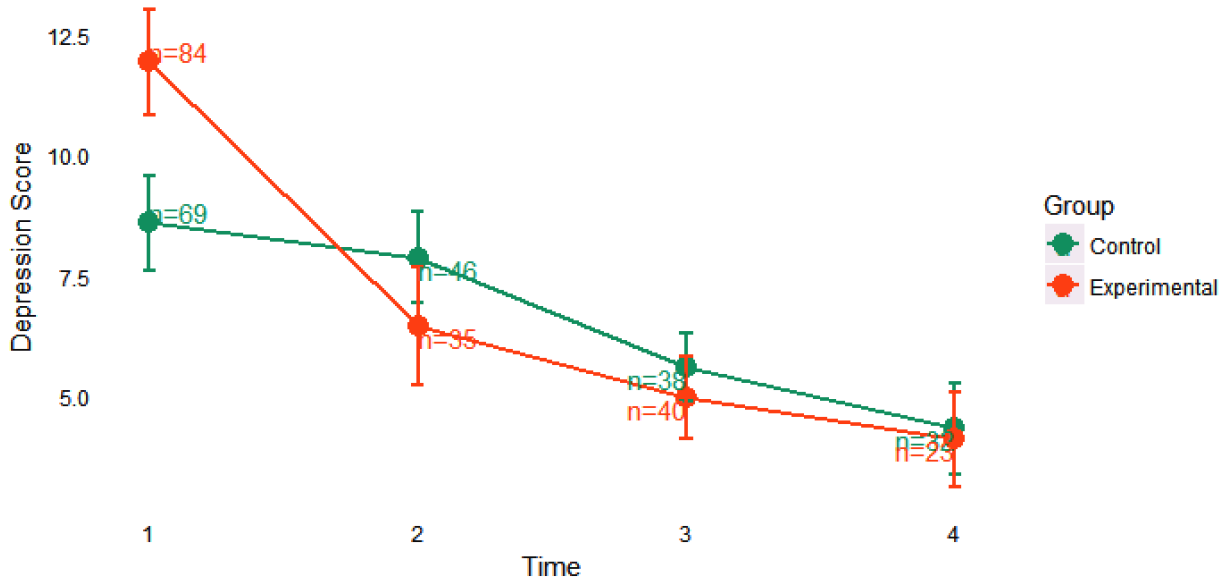


Figure 3. Depression scores over time, stratified by group, with outliers removed.

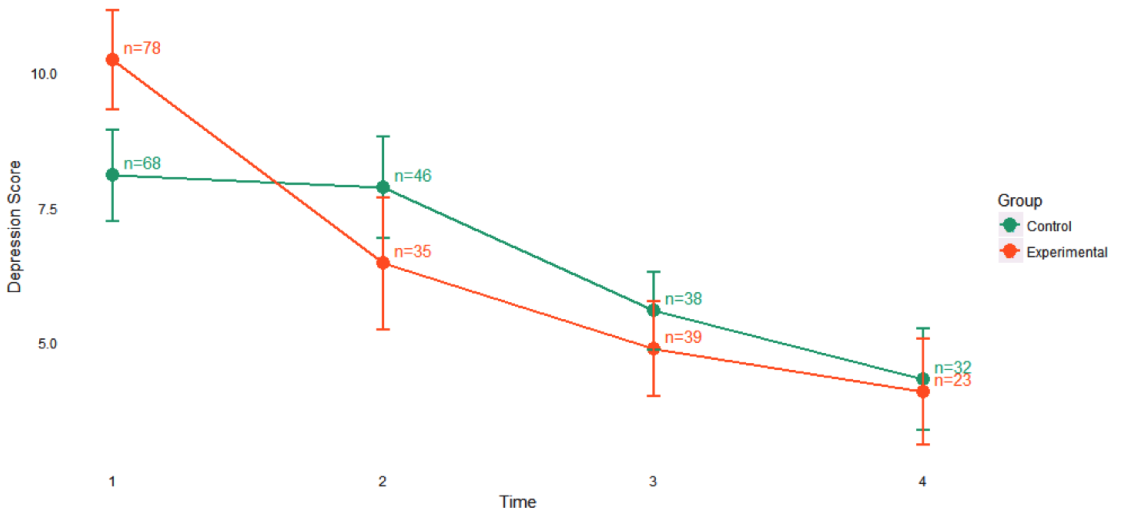
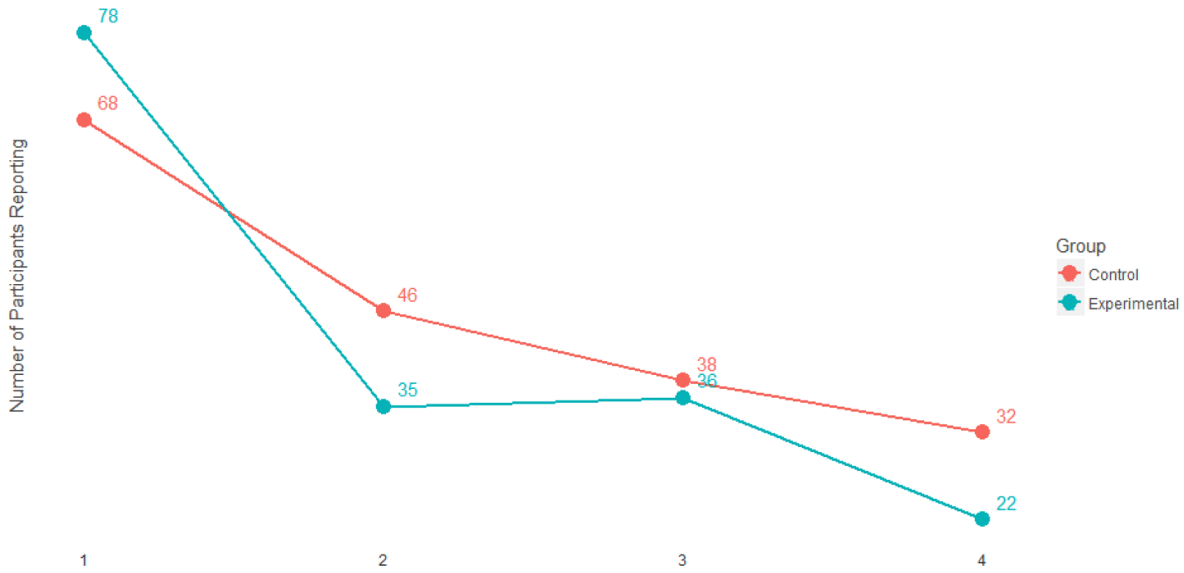


Figure 4. Number of participants who completed assessments during the study period, stratified by group.



Efforts were made to maintain participant engagement throughout the study and collect data for all measures on all occasions. Recent research on Internet-based depression interventions report variable adherence to study arm protocols and often experience high dropout rates [27,28]. Melville et al [27] synthesized 19 peer-reviewed studies referencing attrition among Internet-based behavioral health treatment interventions. Study dropout rates ranged from 2% to 83% and on average, 31% of study participants prematurely exited studies. Given that the pilot study described here was intended to mirror an unguided, real-world design, there was no human outreach component or offer of any financial incentive to increase study participation. Data were missing due to intermittent responses as well as some permanent dropout; all partial data were included in analyses. The overall attrition rate was 62% with 72% of experimental and 53% of the active control observations missing. Figure 4 shows the number of completed assessments in the experimental and active control groups.

Demographic Characteristics

Among the experimental study arm, 75.3% were between 41 and 60 years old, 53.3% were female, 93.5% were Caucasian, and 64.9% were not receiving any mental health treatment. Among the active control arm, 60.3% were between 41 and 60 years old, 57.4% were female, 85.3% were Caucasian, and 60.3% were not receiving any mental health treatment. See Table 1 for the complete demographic characteristics, stratified by group, and for the overall study population.

Table 1. Demographic characteristics of participants (n=145; note: one participant did not answer any demographics questions and was excluded from this table).

Characteristics		Experimental n (%)	Control n (%)	Overall n (%)
Age group				
	18-40 years	15 (19.5)	20 (29.4)	35 (24.1)
	41-60 years	58 (75.3)	41 (60.3)	99 (68.3)
	61+ years	4 (5.2)	7 (10.3)	11 (7.6)
Gender				
	Female	41 (53.3)	39 (57.4)	80 (55.2)
	Male	36 (46.8)	29 (42.7)	65 (44.8)
Ethnicity				
	Caucasian	72 (93.5)	58 (85.3)	130 (89.7)
	African American/black	2 (2.6)	2 (2.9)	4 (2.8)
	Hispanic	1 (1.3)	2 (2.9)	3 (2.1)
	Other	2 (2.6)	6 (8.8)	8 (5.5)
Receiving treatment				
	No	50 (64.9)	41 (60.3)	91 (62.8)
	Yes	27 (35.1)	27 (39.7)	54 (37.2)

Primary Analyses

The primary outcome of interest is change in depression score over time. As shown in Table 2, both the experimental and active control study participants experienced a reduction in depressive symptoms over time. Given that group membership was assigned after informed consent was obtained, it is hypothesized that the pilot study population was more open to help-seeking/treatment than the general population. Also, depressive symptoms, especially mild ones, are well established to eventually decrease even without intervention on their own over time. On average, study participants in the intervention group accessed the myStrength platform 6.09 times during the 26-week study period.

Table 2. Descriptive statistics for depression by group and time.

Outcome		n	Mean	SD	95% CI
Experimental					
	Time 1	78	10.2	8.1	8.40-12.1
	Time 2	35	6.5	7.3	3.96-9.0
	Time 3	36	4.8	4.8	2.84-6.7
	Time 4	22	4.0	4.8	1.86-6.1
Control					
	Time 1	68	8.1	7.0	6.40-9.8
	Time 2	46	7.9	6.4	5.98-9.8
	Time 3	38	5.6	4.4	4.14-7.0
	Time 4	32	4.3	5.3	2.40-6.2

The rate of depression symptom burden improvement was further tested by linear mixed effects regression modeling. A random intercept model was selected to account for individual baseline depression symptoms, and model findings are summarized in Table 3. The intercept is statistically significant, underscoring the importance of taking into account personal depression trajectories (*b* coefficient=4.27, *P*<.001). Receiving mental health treatment, such as outpatient therapy or taking antidepressant medication, was found to be an independent predictor of depression score reduction over time (*b* coefficient=–1.13, *P*=.026). The main effect of time was found to be statistically significant, meaning that in general, a 0.83 reduction in depression score was achieved at each time point (*b* coefficient=–0.83, *P*=.002). This main effect finding is qualified by the interaction group × time (*b* coefficient=–1.35, *P*<.001). Taking into account potential confounders, the experimental arm experienced an accelerated trajectory of

depression symptom reduction to a factor of 1.35 times faster than the active control arm.

Table 3. Summary of mixed effects regression analysis predicting depression.

Effect	Estimate	SE	Degree of freedom	*t* value	*P* value[a]
Intercept	4.27	0.81	303.00	5.26	<.001
Group (experimental)	1.53	0.93	333.60	1.64	.101
Time	–0.83	0.27	296.60	–3.08	.002
Gender (female)	–0.63	0.47	154.20	–1.33	.187
Age group (41-60 years)	–0.29	0.55	149.80	–0.53	.595
Age group (61+ years)	–0.15	0.84	119.20	–0.17	.863
Receiving treatment	–1.13	0.50	158.70	–2.24	.026
Depression baseline	0.72	0.03	146.70	23.56	<.001
Group × time (interaction)	–1.35	0.39	308.90	–3.42	<.001

[a]Satterthwaite approximation was used to estimate degrees of freedom and estimate *P* values. Regression estimates are unstandardized.

Discussion

Principal Findings

Findings from this pilot study support the feasibility of delivering impactful Web- and mobile-based depression interventions directly to employees. This innovative partnership brought together a large commercial health insurance provider, a mid-sized US corporation, and a self-help platform provider of behavioral health and wellness to empower employees with effective self-care tools.

Principal findings suggest that while participants in both study arms experienced improvement in depression symptoms, the experimental arm achieved those favorable results faster and to a greater degree than the active control arm. Within 2 weeks of study enrollment, depression score differences between the two groups emerged with more rapid improvement over time for those participants in the experimental arm. While mean symptom levels began to converge by the 6-month assessment, study participants in the experimental group spent less time being symptomatic compared to the active control group.

In addition, this research supports the premise that evidence-based Web and mobile behavioral health interventions are a viable way to reach employees coping with depressive symptoms who might not otherwise seek out behavioral health care. As seen in Table 1, almost two-thirds of all study participants received no mental health treatment, despite being identified as at risk of depression. This pilot study demonstrated the ability to reach and impact a volunteer, help-seeking population who in the majority of cases were not using other available services. At the same time, the study showed considerable attrition over time. While we hypothesized that individual-level profile-based personalization of the program would drive retention, it appears further work is necessary to overcome this hurdle in order to maximize value from a low-cost, highly scalable, nonguided intervention.

Limitations

This work has several notable limitations. First, due to the real-world, nonincentivized methodology, there was considerable attrition across the pilot study. Barring imputation, we employed statistical approaches that model and control for such attrition; however, it is always possible that subjects lost to follow-up were qualitatively different from those providing follow-up data. If nonresponders in the experimental arm were more likely to drop out of the study, this would certainly have biased the results. Future research building on this pilot study will seek to balance the real-world intent of the program with the possibility of offering incentivized outbound calling or weekly text message reminders to improve study retention.

Selection of a proper control condition is always challenging in behavioral health research. Because participants in such behavioral health research inherently know their assigned intervention arm (myStrength or email series in this case), a well-designed study must incorporate an active control that is equally appealing to participants as the intervention, while not containing the key active ingredients of the intervention [29]. One measure of the effectiveness of an active control is to look for between-group differences in terms of satisfaction with the treatment provided. We asked all participants to rate their satisfaction in each study arm at each reassessment interval. Overall, 93% of study participants in the experimental arm and 73% of study participants who received the active control reported that they were engaged or highly engagement in email campaigns. Given the high satisfaction rates across both groups, the active control email series was considered to be a viable control condition. It was hypothesized that depressive symptom improvement would be achieved in both the experimental and active control groups, given the episodic nature of depression. Research findings substantiated this hypothesized outcome.

In addition, it is possible that myStrength may have variable impact on depression scores among real-world users. Study participants in the experimental arm were required to complete informed consent to participate in this pilot program and theoretically may have been more motivated to use and benefit from such a platform. With only one-third of the sample employee population opting to complete informed consent, we have no additional information on those who chose not to participate to test for selection bias. Building on these early

findings, an observational study is planned to understand the real-world uptake and use of myStrength to minimize this bias.

Finally, the identification and removal of statistical outliers in both study arms at baseline (T1) warrants acknowledgment. Following widely accepted measurement methodology for the identification of outliers, the removal of 7 total outliers was justified. However, the fact that the experimental arm overindexed in outliers might suggest that randomization failed to generate completely equivalent groups—an occurrence that can happen despite randomization. Given the small, pilot nature of this study, future research will employ larger sample sizes to avoid this potential shortcoming.

Conclusions

The results of this pilot study highlight the promise of incorporating self-care tools such as myStrength into the portfolio of behavioral health care offerings. Web and mobile tools are considered complementary, add-on offerings and are not intended to replace face-to-face therapy but rather to expand access to care and to deliver services with lower barriers to entry directly to employees. These preliminary study findings support larger scale efforts to evaluate if employers and their employees could benefit from incorporating an easily accessible and readily available self-care platform to address behavioral health needs.

The myStrength platform may serve as a "just in time" responder preventing mild symptoms from erupting into full-blown clinical depression while easing entry into professional care for those employees grappling with the perceived stigma around diagnosis and seeking treatment. Likewise, the results presented here also suggest that Web and mobile platforms may be a powerful tool for reducing productivity loss due to subclinical behavioral health concerns. myStrength provides low-threshold access to information and evidence-based tools, which could help employees immediately in the short term while also, where appropriate, guiding employees to recognize the need for additional care and avoid costly treatment in the long term.

Acknowledgments

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Conflicts of Interest

Hirsch is a contractor for and Blazejowskyj and Schladweiler are employees of myStrength, the program tested in this pilot study. Hirsch also has ownership interest in myStrength and serves as Chief Clinical Officer to the company. Luellen and Holder, of Centerstone Research Institute, have no financial interests associated with the myStrength product, but the Centerstone Research Institute received compensation for their time on the project from myStrength. Dubiel and Steinberg were employed by Aetna at the time this work was done.

Multimedia Appendix 1

myStrength Web-based log-in interface.

[JPG File, 219KB - resprot_v6i4e51_app1.jpg]

Multimedia Appendix 2

myStrength mobile interface.

[JPG File, 671KB - resprot_v6i4e51_app2.jpg]

Multimedia Appendix 3

Active control informational email example.

[PNG File, 1MB - resprot_v6i4e51_app3.png]

References

1. National Institute of Mental Health. Major Depression Among Adults URL: https://www.nimh.nih.gov/health/statistics/prevalence/major-depression-among-adults.shtml [accessed 2016-12-19] [WebCite Cache ID 6msUXk4WP]
2. Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE. Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005 Jun;62(6):617-627 [FREE Full text] [doi: 10.1001/archpsyc.62.6.617] [Medline: 15939839]
3. Kessler RC, Merikangas KR, Wang PS. The prevalence and correlates of workplace depression in the national comorbidity survey replication. J Occup Environ Med 2008 Apr;50(4):381-390 [FREE Full text] [doi: 10.1097/JOM.0b013e31816ba9b8] [Medline: 18404010]

4. Birnbaum HG, Kessler RC, Kelley D, Ben-Hamadi R, Joish VN, Greenberg PE. Employer burden of mild, moderate, and severe major depressive disorder: mental health services utilization and costs, and work performance. Depress Anxiety 2010;27(1):78-89. [doi: 10.1002/da.20580] [Medline: 19569060]
5. Druss BG, Rosenheck RA, Sledge WH. Health and disability costs of depressive illness in a major U.S. corporation. Am J Psychiatry 2000 Aug;157(8):1274-1278. [doi: 10.1176/appi.ajp.157.8.1274] [Medline: 10910790]
6. Goldberg RJ, Steury S. Depression in the workplace: costs and barriers to treatment. Psychiatr Serv 2001 Dec;52(12):1639-1643. [doi: 10.1176/appi.ps.52.12.1639] [Medline: 11726756]
7. Greenberg PE, Kessler RC, Birnbaum HG, Leong SA, Lowe SW, Berglund PA, et al. The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry 2003 Dec;64(12):1465-1475. [Medline: 14728109]
8. Cooper C, Dewe P. Well-being—absenteeism, presenteeism, costs and challenges. Occup Med (Lond) 2008 Dec;58(8):522-524 [FREE Full text] [doi: 10.1093/occmed/kqn124] [Medline: 19054749]
9. Xerox. Employers invest in technology to promote employee wellbeing though measuring effectiveness proves challenging. URL: https://www.news.xerox.com/news/Xerox-HRS-Survey-on-Technology-for-Employee-Wellbeing [accessed 2016-12-19] [WebCite Cache ID 6msd5AXSA]
10. Biesheuvel-Leliefeld KEM, Kok GD, Bockting CLH, Cuijpers P, Hollon SD, van Marwijk HWJ, et al. Effectiveness of psychological interventions in preventing recurrence of depressive disorder: meta-analysis and meta-regression. J Affect Disord 2015 Mar 15;174:400-410. [doi: 10.1016/j.jad.2014.12.016] [Medline: 25553400]
11. Barrera AZ, Torres LD, Muñoz RF. Prevention of depression: the state of the science at the beginning of the 21st Century. Int Rev Psychiatry 2007 Dec;19(6):655-670. [doi: 10.1080/09540260701797894] [Medline: 18092243]
12. Cuijpers P, Donker T, Johansson R, Mohr DC, van Straten A, Andersson G. Self-guided psychological treatment for depressive symptoms: a meta-analysis. PLoS One 2011;6(6):e21274 [FREE Full text] [doi: 10.1371/journal.pone.0021274] [Medline: 21712998]
13. Adler DA, Lerner D, Visco ZL, Greenhill A, Chang H, Cymerman E, et al. Improving work outcomes of dysthymia (persistent depressive disorder) in an employed population. Gen Hosp Psychiatry 2015;37(4):352-359 [FREE Full text] [doi: 10.1016/j.genhosppsych.2015.04.001] [Medline: 25892151]
14. Buntrock C, Berking M, Smit F, Lehr D, Nobis S, Riper H, et al. Preventing depression in adults with subthreshold depression: health-economic evaluation alongside a pragmatic randomized controlled trial of a Web-based intervention. J Med Internet Res 2017 Jan 04;19(1):e5 [FREE Full text] [doi: 10.2196/jmir.6587] [Medline: 28052841]
15. Wells KB, Schoenbaum M, Duan N, Miranda J, Tang L, Sherbourne C. Cost-effectiveness of quality improvement programs for patients with subthreshold depression or depressive disorder. Psychiatr Serv 2007 Oct;58(10):1269-1278. [doi: 10.1176/appi.ps.58.10.1269] [Medline: 17914002]
16. Spek V, Cuijpers P, Nyklícek I, Riper H, Keyzer J, Pop V. Internet-based cognitive behaviour therapy for symptoms of depression and anxiety: a meta-analysis. Psychol Med 2007 Mar;37(3):319-328. [doi: 10.1017/S0033291706008944] [Medline: 17112400]
17. Titov N, Andrews G, Sachdev P. Computer-delivered cognitive behavioural therapy: effective and getting ready for dissemination. F1000 Med Rep 2010 Jul 14;2:49 [FREE Full text] [doi: 10.3410/M2-49] [Medline: 20948835]
18. Christensen H, Griffiths KM, Jorm AF. Delivering interventions for depression by using the Internet: randomised controlled trial. BMJ 2004 Jan 31;328(7434):265 [FREE Full text] [doi: 10.1136/bmj.37945.566632.EE] [Medline: 14742346]
19. Andrews G, Cuijpers P, Craske MG, McEvoy P, Titov N. Computer therapy for the anxiety and depressive disorders is effective, acceptable and practical health care: a meta-analysis. PLoS One 2010;5(10):e13196 [FREE Full text] [doi: 10.1371/journal.pone.0013196] [Medline: 20967242]
20. Gilbody S, Littlewood E, Hewitt C, Brierley G, Tharmanathan P, Araya R. Computerised cognitive behaviour therapy (cCBT) as treatment for depression in primary care (REEACT trial): large scale pragmatic randomised controlled trial. BMJ 2016 Jan 12;352:i195 [FREE Full text] [Medline: 26759375]
21. Proudfoot J, Goldberg D, Mann A, Everitt B, Marks I, Gray JA. Computerized, interactive, multimedia cognitive-behavioural program for anxiety and depression in general practice. Psychol Med 2003 Feb;33(2):217-227. [Medline: 12622301]
22. Andersson G. Internet-delivered psychological treatments. Annu Rev Clin Psychol 2016;12:157-179. [doi: 10.1146/annurev-clinpsy-021815-093006] [Medline: 26652054]
23. Jakobsen H, Andersson G, Havik O, Nordgreen T. Guided Internet-based cognitive behavioral therapy for mild and moderate depression: a benchmarking study. Internet Interv 2017;7:1-8.
24. myStrength. URL: https://www.mystrength.com/ [accessed 2016-12-19] [WebCite Cache ID 6msghFWna]
25. Shadish W, Cook T, Campbell D. Experimental and Quasi-Experimental Designs for Generalized Causal Inference. 2nd Edition. New York: Wadsworth Publishing; 2001.
26. Henry JD, Crawford JR. The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. Br J Clin Psychol 2005 Jun;44(Pt 2):227-239. [doi: 10.1348/014466505X29657] [Medline: 16004657]
27. Melville KM, Casey LM, Kavanagh DJ. Dropout from Internet-based treatment for psychological disorders. Br J Clin Psychol 2010 Nov;49(Pt 4):455-471. [doi: 10.1348/014466509X472138] [Medline: 19799804]

28. Richards D, Richardson T. Computer-based psychological treatments for depression: a systematic review and meta-analysis. Clin Psychol Rev 2012 Jun;32(4):329-342. [doi: 10.1016/j.cpr.2012.02.004] [Medline: 22466510]
29. Boot WR, Simons DJ, Stothart C, Stutts C. The pervasive problem with placebos in psychology: why active control groups are not sufficient to rule out placebo effects. Perspect Psychol Sci 2013 Jul;8(4):445-454. [doi: 10.1177/1745691613491271] [Medline: 26173122]

Abbreviations

cCBT: computerized cognitive behavioral therapy
DASS-21: Depression, Anxiety, and Stress Scale with 21 items
IRB: institutional review board
RCT: randomized controlled trial

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Protocol

The Impact of Mobile Apps on Alcohol Use Disorder: A Systematic Review Protocol

Antoine SA Sawares[1,2], MD; Nelson Shen[1,3], MHA; Yunlin Xue[1,2], BSc; Alexxa Abi-Jaoude[1], MPH; David Wiljer[1,2,3,4], PhD

[1]Centre for Addiction and Mental Health, Toronto, ON, Canada

[2]University of Toronto, Faculty of Medicine, Toronto, ON, Canada

[3]University of Toronto, Institute of Health Policy, Management and Evaluation, Toronto, ON, Canada

[4]University Health Network, Toronto, ON, Canada

Corresponding Author:
David Wiljer, PhD
University Health Network
190 Elizabeth Street, Room 441
Toronto, ON, M5G 2C4
Canada
Phone: 1 416 340 6322
Fax:
Email: David.wiljer@uhn.ca

Abstract

Background: Alcohol use disorder (AUD) is among the most prevalent mental disorders worldwide and is associated with a diverse range of physical and psychological comorbidities. Despite various types of treatment, there are many barriers to accessing treatment (ie, stigma, cost, accessibility of service, etc). Mobile apps have the potential to overcome these barriers and provide support to those who need it.

Objective: The purpose of this systematic review is to assess the effectiveness of mobile apps in reducing alcohol consumption for individuals with AUD and understand the psychological outcomes of using the apps (ie, client empowerment, self-efficacy, etc).

Methods: The search strategy was applied to 7 health sciences and interdisciplinary databases. Two reviewers will independently assess all titles and abstracts for relevance and then full texts of relevant articles for eligibility. To be included, the article must be a quantitative evaluation of clinical outcomes using the intervention and the intervention must be a consumer-facing app focused on supporting individuals with AUD. Two reviewers will independently extract data from all eligible articles using a standardized extraction worksheet and will independently assess the study quality. A meta-analysis will be conducted if appropriate. Depending on outcomes reported, pooled risk ratios or standardized mean differences will be calculated and reported in the review.

Results: The search strategy yielded 699 unique citations. Of those, 63 (9.0%, 63/699) articles were assessed as relevant for full-text review. The full-text reviews are currently underway and the final review is projected to be completed in the summer of 2017.

Conclusions: There is potential for mobile apps to support individuals with AUD to reduce their alcohol consumption. This review will be the first to assess the effectiveness of AUD mobile apps and client experiences using the apps.

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KEYWORDS

mobile health; apps; alcohol use disorder; systematic review; protocol; mental health; addiction; alcoholism

Introduction

In many cultures, the consumption of alcohol is considered a social norm. While there are beneficial effects of moderate consumption, including decreased risk for heart disease, ischemic stroke, and diabetes [1], research has shown many risks associated with alcohol use linked to heavy drinking patterns [2]. In 2010, the global per capita consumption of

alcohol (ages 15 and up) was equivalent to 6.2 liters of pure alcohol consumed per calendar year. Furthermore, 16.0% of those drinkers engaged in heavy episodic drinking [3]. Alcohol-related harm is determined by the volume of alcohol consumed, the pattern of drinking, and, on rare occasions, the quality of alcohol consumed. According to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) alcohol use disorder (AUD) is a problematic pattern of alcohol use defined by specific diagnostic criteria including a cluster of behavioral and physical symptoms leading to clinically significant impairment or distress. Previous DSM editions defined problematic alcohol use through two distinct categories: abuse and dependence [4].

AUD is among the most prevalent mental disorders worldwide and contributes substantially to global morbidity and mortality [5,6]. The World Health Organization estimated that over three million deaths per year are linked to AUD—slightly more than lung cancer and HIV/AIDS mortalities combined [3]. Alcohol use has been associated with diverse physical and psychiatric comorbidities. It is affiliated with over 200 different diseases, conditions, and injuries [7]. Among those who drink heavily, women tend to experience more heart, liver, and brain damage from alcohol compared to men [8]. In addition to disease risk, alcohol consumption could also lead to financial burdens for the drinker and harm others around them [2].

Over the years, numerous therapeutics for alcohol management have been developed. The interventions range from various types of counseling, for example, brief intervention [9] or motivational interviewing [10], to using anti-craving medication (eg, Naltrexone and Acamprosate) [11]. While counseling primarily targets behavioral changes, pharmacological agents alter physiological responses to alcohol intake. Despite the various types of treatments available, there are many barriers to accessing treatment. For non-treatment seekers, stigma and cost of treatment are reported to be the main barriers. For treatment seekers, stigma is a significant barrier. In addition, barriers to treatment include long wait-times and a limited number of trained personnel [12]. Brief intervention is a treatment that faces this limitation. Potential issues regarding pharmacotherapy include side effects, lack of continuous monitoring, and potentially low patient compliance [13].

Emerging technologies have the potential to address the barriers of current forms of treatment. The development and ubiquity of the Internet, bolstered by the subsequent advent of smart devices, cultivated a global environment of hyper-connectivity and increased access to information. Increasingly, we see mobile health (mHealth) interventions aiming to address a myriad of mental health and substance use issues by leveraging the increased functionality of mobile devices and mobile phones with app capabilities (smartphones). A significant shift has occurred in the mHealth field, moving primarily from telephone calls and short message service (SMS) interventions to a wide scope of mobile apps with multiple functions and features [14]. These robust mHealth interventions can now provide user-friendly and accessible tools such as evidence-based information and guidelines, personalized reminders, self-assessment tools, goal setting and tracking tools, online resources (eg, webpages, discussion groups, etc), and, with user's consent, geolocation services to alert users of "high risk" locations [15]. The use of these mobile apps have a significant role in overcoming barriers that lead to attrition of patient participation in traditional AUD treatment programs. Despite this potential, the effectiveness of AUD apps is not well understood. A recent systematic review [16] on mobile technology-based interventions for adult users of alcohol found studies reporting positive effects (eg, reduction in drinking and readiness to change); however, the review focused on all mobile technology interventions including Web- and SMS-based interventions. This proposed systematic review specifically aims to understand the impact of app-based interventions on individuals endorsing symptoms for AUD.

Methods

The purpose of this systematic review is to assess the effectiveness of app-based interventions in reducing alcohol consumption for individuals with AUD and to understand the client experience. Using a population, intervention, comparator, outcomes (PICO) [17] method to frame the research question, this review aims to determine the effects of mobile apps (intervention) for individuals with AUD (population) compared to a baseline or a control group (comparator, if available) on reducing alcohol consumption (outcome). A secondary objective is to identify other effects related to supporting self-management behaviors or behavior change (eg, self-efficacy, patient activation, patient experience, attrition, sustained use, etc). This systematic review protocol was written using the PRISMA-P statement [17] as a guide and was registered with the PROSPERO database of systematic reviews (#CRD42016049957).

Search Strategy

The search strategy will be developed in consultation with a health information specialist (SL) at the Centre for Addiction and Mental Health in Toronto, Canada. The search strategy will be first developed for Medline and then translated to query 5 other databases. A mHealth search hedge comprised of the Medline MeSH terms (ie, "Computers/Handheld", "Mobile Applications/", "Cell Phones", "Text Messaging") and Boolean objects for mobile phones (eg, "(cellphone app* or phone app* or smartphone app*).mp ") will serve as the foundation of the search. The query will be added to a search for alcohol-related disorder (ie, "alcohol drinking/ or binge drinking/" or "alcohol-related disorders/ or alcoholic intoxication/ or alcoholism/" or "binge drink*.mp) using the "AND" operator. The search will be restricted from 2007 to January 14th, 2016. The year 2007 was selected because this marked the introduction of the Apple iPhone and the popularization of the mobile phone app ecosystem [14]. A second search was conducted during the week of July 15th, 2016 to capture more recent citations.

The search will be applied to 5 health sciences databases (Medline, MEDLINE-IP, PsycINFO, EMBASE, CINAHL). Interdisciplinary databases (Scopus and Web of Science) will also be queried to capture publications from other disciplines such as computer and information systems sciences. If the search results include conference abstracts and proceedings, a search for follow-up articles to the conference abstracts will be

conducted on Google Scholar. Lastly, the reference lists of relevant systematic reviews will be hand-combed to identify articles that may be of relevance to this review.

The results from the search will be exported in ".ris" format to import results into a Mendeley citation manager where duplicate citations are de-duplicated using the citation manager. Results from the databases will also be exported as ".xls" files to use as a foundation to develop the screening forms. Additional results from the hand searching and follow-up will be added to Mendeley and documented in a separate spreadsheet. All spreadsheets will be collated into one workbook and developed into a screening form for selecting articles.

Selection Criteria

Two rounds of screening will be conducted by the two reviewers (AS and YX) to determine the eligibility of a citation or article. Every article will be rated independently by both reviewers and documented on a screening spreadsheet. At the end of each round, the ratings will be compared and discrepancies resolved first by consensus between the reviewers or by a third reviewer (NS) if consensus cannot be reached.

Articles will be first assessed for relevance based on a scan of the title and abstract. Articles meeting all of the inclusion criteria (Textbox 1) will be labeled as potentially relevant and qualified for full-text review. Articles will be excluded if they meet any of the exclusion criteria (Textbox 1).

Textbox 1. Inclusion and exclusion criteria.

Criteria

- Inclusion criteria
  - a quantitative primary study
  - focused on supporting individuals with alcohol use disorder (AUD), alcohol abuse, or alcohol dependence [4]
  - a consumer-facing app (ie, not for clinician support)
- Exclusion criteria
  - the mobile intervention is only SMS-based, Web-based, or uses interactive voice response (IVR)
  - the mobile app is used as a screening tool rather than an intervention
  - the study is not alcohol specific (ie, addresses poly-substance use and/or addictive behaviors such as gambling, sex, eating, etc)

The full-text review will be used to corroborate the eligibility of "potentially relevant" and hand-searched articles. To be included, the full-text must be in English and the study must be a formal empirical evaluation of the clinical outcomes of using the intervention, where experimental and quasi-experimental designs were included. Formative evaluations, such as usability studies or needs assessments, were excluded.

Data Extraction

A standardized data extraction form developed by the research team will be used to extract data. The form will be pre-piloted by the two reviewers to ensure there is a common understanding of the categories and formatting for extraction. The extracted information will follow the PICO framework. The study details, population, intervention, and comparator data will be extracted as reported by the article under their respective headings and subheadings. The intervention subheadings will focus on the app design elements (ie, functions, content, and theoretical foundation) and the implementation of the app for the study (ie, dosage and/or duration and human interaction). App functions will include psychoeducation (ie, information), medical assessment, symptom management, supportive resources (ie, peer and/or provider support), therapeutic treatment (ie, behavior change support), and other [18-20]. The other category will be for instances where the function does not fit under the prescribed categories. A list of headings, subheadings, descriptions, and examples of extraction format is provided in Table 1.

Table 1. Extraction form elaboration table.

PICO[a] category		Instruction and/or definition
Study details		
	Study year	When was this study conducted?
	Country	Where is the study from (ie, country)?
	Study design	What type of study was it, as described by article?
	Follow-up	How long was the intervention? And additional follow-up?
	Outcome measures	What did the authors identify as their outcome measures?
	Use of theory	Did the evaluation use theory?
Population		
	Descriptor	What was the study population, as described by the article?
	Inclusion criteria	Are there specific symptoms or patient characteristics?
	Age	What was the average age (or majority age range for majority)?
	Sampling strategy	What was the sampling strategy (ie, randomized, convenience)?
	Sampling frame	Where were participants sampled from?
	Sample size	Was the ratio of completion to recruited reported?
Intervention		
	Intervention name	What is the name of the app?
	App functions description	What does the app do (ie, psychoeducation, medical assessment, symptom management, supportive resources, therapeutic treatment, and "other")?
	App content	Is there an information component and what topics are provided?
	Theoretical foundation	What theory or model was used for the intervention?
	Duration/dose	Was there prescribed use? If so, what was it, how often, and for how long?
	Human interaction	Did the intervention include interaction with peers or healthcare providers?
Outcomes		
	Primary outcome	What were the primary outcome(s) results, categorized as an "outcome evaluation" or "assessment of drinking behavior"?
	Secondary outcomes	What were the secondary outcome(s) results?

[a]PICO: population, intervention, comparator, outcomes.

The primary outcome of interest is the reduction in alcohol consumption. Based on the domains outlined by the National Institute of Alcohol Abuse and Alcoholism (NIAAA) [16], these outcomes are classified under the "outcome evaluation" and "assessment of drinking behavior" domains. The outcome evaluation domain pertains to the measures that are the end results of treatment, such as the Drinking Problems Index (DPI), the Alcohol Timeline Follow Back (TLFB), and the Addiction Severity Index (ASI). The assessment of drinking behavior domain consists of measures which assess the quantity, frequency, intensity, and pattern of alcohol consumption, for example, the Drinking Self-Monitoring Log (DSML). The secondary outcomes of interest will include measures under the NIAAA "treatment and process assessment" domain. The measures under this domain focus on understanding the process of treatment such as treatment atmosphere, degree of treatment structure, and the immediate goals or proximal outcomes of treatment, for example, the Treatment Services Review (TSR). Measures related to client experience (eg, self-efficacy, patient activation, and patient experience) are also of interest. In addition, participant attrition is a secondary outcome of interest; however, this outcome will be extracted under the population domain.

Data Analysis

A narrative synthesis of all included articles will be outlined in tables and will include study details, sample characteristics, description of app-based interventions, and outcomes. A meta-analysis will be performed if feasible. Depending on outcomes reported, this review will calculate and report pooled risk ratios or standardized mean differences. Fowler et al [16] found many of the studies in their review did not provide the appropriate data for meta-analysis and that there was too much heterogeneity in populations, interventions, and outcome measures. Based on this observation, effect sizes will be calculated for articles that did not report them using the reported data (ie, test statistics or probability values) to calculate the appropriate metric [21]. Furthermore, a random effects model will be performed since it is anticipated that the included studies may be heterogeneous. The results will be assessed using the

evolution of heterogeneity (I^2) statistic [22,23]. A sensitivity analysis will be conducted based on study quality and study design to investigate the source of heterogeneity. Furthermore, a subgroup analysis to explore heterogeneity of the estimated effect sizes will be conducted based on the following characteristics: study quality, severity of AUD in participants, length of intervention, type of control condition, attrition rates, intervention characteristics (automated versus health care provider involvement, theoretical or atheoretical, dosage/duration), and patient experiences (ie, satisfaction, activation, and self-efficacy). Evidence of publication bias will be assessed through funnel plots.

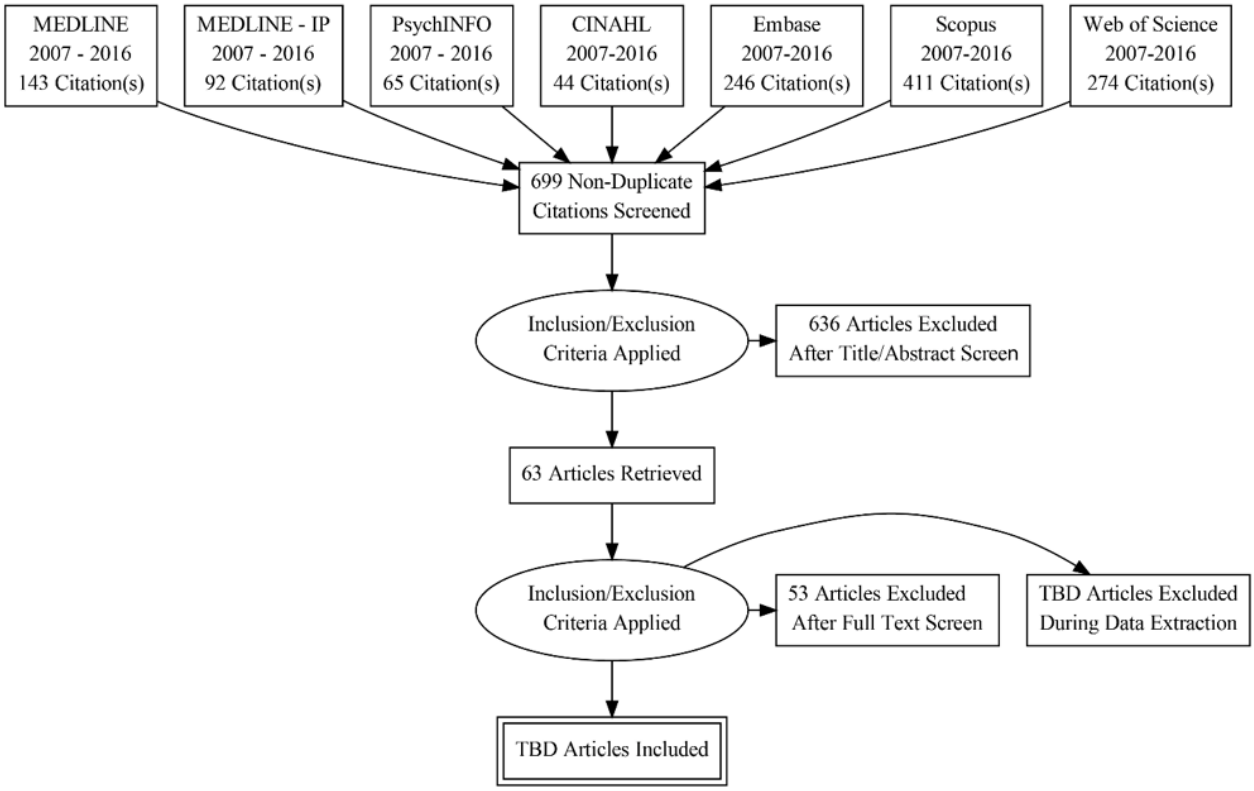
Quality Assessment

Two reviewers will independently assess the risk of bias in the included studies using the Scottish Intercollegiate Guidelines Network (SIGN) 50 critical appraisal checklists for randomized controlled trials (RCTs) and observational studies [24]. The SIGN 50 tools were selected following recommendations made by the Canadian Agency for Drugs and Technology in Health (CADTH) [25] and were based on a systematic review followed by expert and stakeholder consultation/vetting processes on the quality of the identified quality appraisal tools. The assessments will be compared and disagreements will be resolved by consensus or third reviewer if necessary.

Results

The initial search yielded 1076 articles of which 570 (52.97%, 570/1076) were unique citations. The second search added an additional 129 (64.8%, 129/199) unique citations. After applying the inclusion and exclusion criteria to the title and abstracts, 63 (9.0%, 63/699) citations were assessed as potentially relevant for full-text review. The hand-searching yielded 6 citations to be included in the full-text review. To date, the reviewers have included 10 articles and will begin data extraction and quality assessments. The progress to date is outlined in Figure 1. This review is projected to be completed in the summer of 2017.

Figure 1. Preliminary PRISMA flow diagram (progress to date).



Discussion

Principal Findings

There is great potential for apps to support individuals with AUD. However, the efficacy or effectiveness of these apps, or apps in general, is not well understood because the research has yet to catch up to the ever-evolving and expanding mHealth landscape. In 2012, a study found 44 of 500 alcohol-related mobile phone apps available in the Apple and Android marketplaces focused on alcohol reduction [26]. A follow-up review [27] found the number of alcohol-reduction apps (n=91) doubled in two years and that 16.4% of the apps identified (n=662) mentioned evidence in their descriptions. While there are no systematic reviews evaluating the effectiveness of mobile apps, reviews found that electronic interventions (e-interventions) for alcohol misuse in general have short-term benefits in reducing alcohol consumption [28-32]. A recent systematic review [16] of mobile-based interventions for adult alcohol users found only 2 studies on the effectiveness of alcohol reduction/cessation apps, as the remaining articles focused on SMS-based interventions. This review will build on the efforts by Fowler et al [16] by focusing on evaluations of app-based

interventions for AUD by expanding the search strategy and including a wider range of study designs.

Conclusion

This systematic review will be the first to determine the effectiveness of app-based interventions to reduce alcohol consumption for individuals with AUD. While the primary focus will be clinical outcomes, this study will also seek to understand whether using the app will have any positive psychological outcomes in the form of empowerment or self-efficacy and whether these apps provide the support needed to sustain use. Engagement with the app is important if behavior change is to occur, especially with many digital interventions experiencing high rates of attrition [27,33]. Understanding these secondary factors will provide insights on the behavioral mechanism required to reduce alcohol consumption and whether there are gaps between app concept, delivery, and translation into behavior change and alcohol use reduction [33].

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Conflicts of Interest

None declared.

References

1. Scientific Report of the 2015 Dietary Guidelines Advisory Committee. 2015. URL: https://health.gov/dietaryguidelines/2015-scientific-report/pdfs/scientific-report-of-the-2015-dietary-guidelines-advisory-committee.pdf [WebCite Cache ID 6pHNzrrIV]
2. Rehm J. The risks associated with alcohol use and alcoholism. Alcohol Res Health 2011;34(2):135-143 [FREE Full text] [Medline: 22330211]
3. World Health Organization. Global Status Report on Alcohol and Health 2014. 2014. URL: http://apps.who.int/iris/bitstream/10665/112736/1/9789240692763_eng.pdf?ua=1 [WebCite Cache ID 6pHPqTGsO]
4. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Arlington, VA: American Psychiatric Publishing; 2013.
5. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012 Dec 15;380(9859):2095-2128. [doi: 10.1016/S0140-6736(12)61728-0] [Medline: 23245604]
6. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012 Dec 15;380(9859):2197-2223. [doi: 10.1016/S0140-6736(12)61689-4] [Medline: 23245608]
7. Rehm J, Mathers C, Popova S, Thavorncharoensap M, Teerawattananon Y, Patra J. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. Lancet 2009 Jun 27;373(9682):2223-2233. [doi: 10.1016/S0140-6736(09)60746-7] [Medline: 19560604]
8. Bingham RJ. Latest evidence on alcohol and pregnancy. Nurs Womens Health 2015;19(4):338-344. [doi: 10.1111/1751-486X.12219] [Medline: 26264798]
9. D'Onofrio G, Degutis LC. Preventive care in the emergency department: screening and brief intervention for alcohol problems in the emergency department: a systematic review. Acad Emerg Med 2002 Jun;9(6):627-638 [FREE Full text] [Medline: 12045080]
10. Vasilaki EI, Hosier SG, Cox WM. The efficacy of motivational interviewing as a brief intervention for excessive drinking: a meta-analytic review. Alcohol Alcohol 2006;41(3):328-335. [doi: 10.1093/alcalc/agl016] [Medline: 16547122]
11. Bouza C, Angeles M, Magro A, Muñoz A, Amate JM. Efficacy and safety of naltrexone and acamprosate in the treatment of alcohol dependence: a systematic review. Addiction 2004 Jul;99(7):811-828. [doi: 10.1111/j.1360-0443.2004.00763.x] [Medline: 15200577]
12. Wallhed FS, Bakshi A, Andréasson S. Alcohol consumption, dependence, and treatment barriers: perceptions among nontreatment seekers with alcohol dependence. Subst Use Misuse 2014 May;49(6):762-769. [doi: 10.3109/10826084.2014.891616] [Medline: 24601784]
13. Volpicelli JR, Volpicelli LA, O'Brien CP. Medical management of alcohol dependence: clinical use and limitations of naltrexone treatment. Alcohol Alcohol 1995 Nov;30(6):789-798. [Medline: 8679021]
14. Hooker D, Shen N, Kendall H. Leveraging community for mHealth research and development. In: Technology Enabled Knowledge Translation for eHealth. New York: Springer New York; 2012:153-174.
15. Gustafson DH, Boyle MG, Shaw BR, Isham A, McTavish F, Richards S, et al. An e-health solution for people with alcohol problems. Alcohol Res Health 2011;33(4):327-337 [FREE Full text] [Medline: 23293549]
16. Fowler L, Holt S, Joshi D. Mobile technology-based interventions for adult users of alcohol: a systematic review of the literature. Addict Behav 2016 Nov;62:25-34. [doi: 10.1016/j.addbeh.2016.06.008] [Medline: 27310031]

17. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ 2015 Jan 02;349:g7647 [FREE Full text] [Medline: 25555855]
18. Luxton DA, McCann RA, Bush NE, Mishkind MC, Reger GM. mHealth for mental health: integrating smartphone technology in behavioral healthcare. Prof Psychol Res Pr 2011;42(6):505-512. [doi: 10.1037/a0024485]
19. Shen N, Levitan M, Johnson A, Bender JL, Hamilton-Page M, Jadad AA, et al. Finding a depression app: a review and content analysis of the depression app marketplace. JMIR Mhealth Uhealth 2015 Feb 16;3(1):e16 [FREE Full text] [doi: 10.2196/mhealth.3713] [Medline: 25689790]
20. Murray E, Burns J, See TS, Lai R, Nazareth I. Interactive Health Communication Applications for people with chronic disease. Cochrane Database Syst Rev 2005 Oct 19(4):CD004274. [doi: 10.1002/14651858.CD004274.pub4] [Medline: 16235356]
21. Field AP, Gillett R. How to do a meta-analysis. Br J Math Stat Psychol 2010 Nov;63(Pt 3):665-694. [doi: 10.1348/000711010X502733] [Medline: 20497626]
22. Higgins JPT, Green S, editors. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [Updated March 2011]. London: The Cochrane Collaboration; 2011.
23. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003 Sep 06;327(7414):557-560 [FREE Full text] [doi: 10.1136/bmj.327.7414.557] [Medline: 12958120]
24. Scottish Intercollegiate Guidelines Network. URL: http://www.sign.ac.uk/methodology/checklists.html [accessed 2017-03-27] [WebCite Cache ID 6pHUqIL3p]
25. Bai A, Shukla VK, Bak G, Wells G. Quality Assessment Tools Project Report. Ottawa: Canadian Agency for Drugs and Technology in Health; 2012. URL: https://www.cadth.ca/media/pdf/QAT_final.pdf [WebCite Cache ID 6pHUz0CtW]
26. Weaver ER, Horyniak DR, Jenkinson R, Dietze P, Lim MS. "Let's get Wasted!" and other apps: characteristics, acceptability, and use of alcohol-related smartphone applications. JMIR Mhealth Uhealth 2013 Jun 25;1(1):e9 [FREE Full text] [doi: 10.2196/mhealth.2709] [Medline: 25100681]
27. Crane D, Garnett C, Brown J, West R, Michie S. Behavior change techniques in popular alcohol reduction apps: content analysis. J Med Internet Res 2015 May 14;17(5):e118 [FREE Full text] [doi: 10.2196/jmir.4060] [Medline: 25977135]
28. Rooke S, Thorsteinsson E, Karpin A, Copeland J, Allsop D. Computer-delivered interventions for alcohol and tobacco use: a meta-analysis. Addiction 2010 Aug;105(8):1381-1390. [doi: 10.1111/j.1360-0443.2010.02975.x] [Medline: 20528806]
29. Riper H, Spek V, Boon B, Conijn B, Kramer J, Martin-Abello K, et al. Effectiveness of E-self-help interventions for curbing adult problem drinking: a meta-analysis. J Med Internet Res 2011 Jun 30;13(2):e42 [FREE Full text] [doi: 10.2196/jmir.1691] [Medline: 21719411]
30. Riper H, Spek V, Boon B, Conijn B, Kramer J, Martin-Abello K, et al. Effectiveness of E-self-help interventions for curbing adult problem drinking: a meta-analysis. J Med Internet Res 2011 Jun 30;13(2):e42 [FREE Full text] [doi: 10.2196/jmir.1691] [Medline: 21719411]
31. Donoghue K, Patton R, Phillips T, Deluca P, Drummond C. The effectiveness of electronic screening and brief intervention for reducing levels of alcohol consumption: a systematic review and meta-analysis. J Med Internet Res 2014 Jun 02;16(6):e142 [FREE Full text] [doi: 10.2196/jmir.3193] [Medline: 24892426]
32. Dedert EA, McDuffie JR, Stein R, McNiel JM, Kosinski AS, Freiermuth CE, et al. Electronic interventions for alcohol misuse and alcohol use disorders: a systematic review. Ann Intern Med 2015 Aug 04;163(3):205-214 [FREE Full text] [doi: 10.7326/M15-0285] [Medline: 26237752]
33. Zhao J, Freeman B, Li M. Can mobile phone apps influence people's health behavior change? An evidence review. J Med Internet Res 2016 Oct 31;18(11):e287 [FREE Full text] [doi: 10.2196/jmir.5692] [Medline: 27806926]

Abbreviations

AUD: alcohol use disorder
mHealth: mobile health
NIAAA: National Institute of Alcohol Abuse and Alcoholism
PICO: population, intervention, comparator, outcomes
SIGN: Scottish Intercollegiate Guidelines Network

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Proposal

Analyzing Unstructured Communication in a Computer-Mediated Environment for Adults With Type 2 Diabetes: A Research Protocol

Allison A Lewinski[1*], MPH, RN; Ruth A Anderson[2*], PhD, RN, FAAN; Allison A Vorderstrasse[1*], DNSc, APRN, FAAN; Edwin B Fisher[3,4*], PhD; Wei Pan[1*], PhD; Constance M Johnson[5*], PhD, RN, FAAN

[1]Duke University School of Nursing, Durham, NC, United States

[2]School of Nursing, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

[3]Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

[4]Peers for Progress, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

[5]School of Nursing, The University of Texas Health Science Center at Houston, Houston, TX, United States

[*]all authors contributed equally

Corresponding Author:
Allison A Lewinski, MPH, RN
Duke University School of Nursing
307 Trent Drive
DUMC 3322
Durham, NC, 27710
United States
Phone: 1 919 684 9198
Fax: 1 919 684 9350
Email: allison.lewinski@duke.edu

Abstract

Background: Individuals with type 2 diabetes have an increased risk for comorbidities such as heart disease, lower limb amputations, stroke, and renal failure. Multiple factors influence development of complications in a person living with type 2 diabetes; however, an individual's self-management behaviors may delay the onset of, or lessen the severity of, these complications. Social support provides personal, informal advice and knowledge that helps individuals initiate and sustain self-management and adherence.

Objective: Our aim was to gain an understanding of type 2 diabetes social interaction in a virtual environment, one type of computer-mediated environment (CME), and the social support characteristics that increase and sustain self-management in adults living with chronic illness.

Methods: This study is a secondary analysis of longitudinal data collected in a CME study, Second Life Impacts Diabetes Education & Self-Management (1R21-LM010727-01). This virtual environment replicated a real-life community where 6 months of naturalistic synchronous voice conversations, emails, and text chats were recorded among participants and providers. This analysis uses a mixed-methods approach to explore and compare qualitative and quantitative findings. This analysis is guided by two theories: Strong/Weak Ties Theory and Social Penetration Theory. Qualitative data will be analyzed using content analysis, and we will complete descriptive statistics on the quantified variables (eg, average number of ties). Institutional review board approval was obtained in June 2016.

Results: This study is in progress.

Conclusions: Interventions provided through virtual environments are a promising solution to increasing self-management practices. However, little is known of the depth, breadth, and quality of social support that is exchanged and how interaction supports self-management and relates to health outcomes. This study will provide knowledge that will help guide clinical practice and policy to enhance social support for chronic illness via the Internet.

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KEYWORDS

diabetes type 2; social support; adults; Internet; peer support; self-management; mixed methods; social interaction; secondary analysis

Introduction

Type 2 diabetes (T2D) affects 9.3% of the adult population in the United States and is the 7th leading cause of death [1]. The Centers for Disease Control and Prevention estimates an additional 8.1 million US adults are living with T2D, yet remain undiagnosed [1]. Complications of T2D include renal failure, lower limb amputations, and heart disease [1]; such complications are associated with an individual's self-management behaviors [2-4]. Regular preventative care is also essential to preventing comorbidities and maintaining a baseline level of health [5]. However, no greater than 75% of adults report receiving standard, recommended T2D preventive care, such as vaccinations, annual eye exams, at least an annual glycosylated hemoglobin (HbA1c) test, and regular foot examinations [1]. Due to the increasing incidence and prevalence of T2D, health care providers and researchers need to explore innovative, accessible, and lower cost ways to enhance the self-management skills of those living with T2D [6,7].

Self-management of T2D is person-specific, ever-present, and dynamic [2], as individuals with T2D provide 99% of their own self-care [8]. Thus, daily disease management of T2D depends on an individual's self-management behaviors and knowledge [2]. In addition to T2D specific skills and knowledge, research indicates that psychosocial support is important in maintaining self-management behaviors [9,10]. As such, interventions that provide additional support to facilitate self-management are essential, as individuals living with T2D report not receiving desired psychosocial support from close family and peers [11].

Background

Individuals living with T2D can become knowledgeable about self-management behaviors and living with a chronic illness through social interactions with peers and providers [12]. Studies indicate that sustained support from peers and providers for T2D self-management is effective in lowering HbA1c levels because it reinforces critical self-management skills [7,10,13]. Table 1 provides definitions for terms utilized in this study [14-24].

Table 1. Terms used in this study.

Term	Definition for this study
Self-management behaviors	Daily activities completed by the individual living with T2D, which may include [14-16]: monitoring dietary intake, checking blood glucose values, medication adherence, physical activity, foot care
Social interaction	A bidirectional, verbal, or written exchange between two or more individuals on a mutually shared, central topic [17-19]
Social support	Personal, informal advice and knowledge that help individuals initiate and sustain T2D self-management behaviors, thus increasing adherence [20-22]
Computer-mediated environment	A computer medium that mediates communication among individuals [23,24]: email, discussion forums, text messaging, virtual environments

Self-management of T2D improves with increased frequency of social interaction [25-27]. Research indicates that high frequency interaction, over an extended period of time, with peers or health care professionals can impact and change self-management strategies and blood glucose levels in T2D interventions [6]. Social interaction is important in self-management as individuals provide real-world assistance to those with T2D. Key to this relationship is the mutual understanding of the shared experience of living with T2D [22,28-30]. Individuals may exchange support as well as obtain information from others during these synchronous and asynchronous interactions [20,31,32]. Social interactions enable individuals to verbalize this acquired knowledge [33,34].

Of note, an individual's behavior can be influenced due to a social interaction [31,35]. Verbalizing a personal narrative influences self-management skills, emotional expression, health outcomes, and social support; the language used denotes an individual's perspective and meaning of these situations [32,36-40]. However, frequent levels of interaction and support are not always feasible in traditional health care settings due to the temporal and financial constraints on both the individuals and provider [6,41,42]. Thus, using the Internet for social interaction is a potential solution and can include interaction among peers as well as between the individuals and provider.

Internet interventions are more widely accessible than other forms of health care [43]. Individuals access information and interact with an online community of support [44,45] and gain quality information to aid in the self-management of T2D [44-46]. Therefore, interventions provided via computer-mediated environments (CMEs) are a promising solution to increase self-management practices [47,48]. Current CME interventions to improve T2D self-management include mHealth [45,49], programs via the Internet [45,49], and telemonitors [50]. In CMEs, individuals gain information and benefit from being present with others [51]; their participation is both active (present, talking) and passive (present, not talking). Information gleaned through these online interactions supplements and enhances real-world knowledge, processes, and experiences [52-54].

Despite obtaining useful self-management skills and knowledge, attrition in T2D self-management programs remains a concern. Reasons for attrition include barriers that may be temporal (eg, working full- or part-time, scheduling conflicts), geographical (eg, distance to program), emotional (eg, apathy, priority of self-management), or technological (eg, engagement, computer problems) [25,55,56]. Internet interventions can address many of these barriers to attendance, thus potentially decreasing attrition in self-management interventions. Unfortunately, the rates of T2D self-management remain suboptimal, and Internet

intervention studies to improve self-management report inconsistent findings in both short- and long-term effectiveness and sustainability [3,26,49,57,58]. Mixed results may stem from not having synchronous conversations in social interaction, which would provide sufficient depth and breadth in social support or not having the ability to obtain this type of support at convenient times [16].

A virtual environment focusing on T2D-specific self-management skills may influence the real-time social interactions among individuals and the support exchanged [16]. Virtual environments mimic real-world environments. The virtual environment is exploratory, interactive, extensive, and users can ultimately determine their own personal involvement and investment [59]. This computer-generated environment provides an illusion of the real world through a multisensory, interactive encounter, in which users feel *presence* and *co-presence* [60,61]. Presence, the feeling of being "there" in the environment, makes it feel as if the actions in the CME were occurring in the real world, and the user is completely engaged in the CME [60-62]. Co-presence is the feeling that others are present in the virtual environment and that one is in an interactive environment where interpersonal relationships can be initiated, formed, and maintained [60,61]. While virtual environments can have many different types of representations (eg, small towns, space crafts) and facilitate a variety of interactions, the proposed study describes a virtual environment as one that recreates a small town using three-dimensional graphics [61]. The replication of real-life environments can foster skills that promote real-world application of essential self-management behaviors [16].

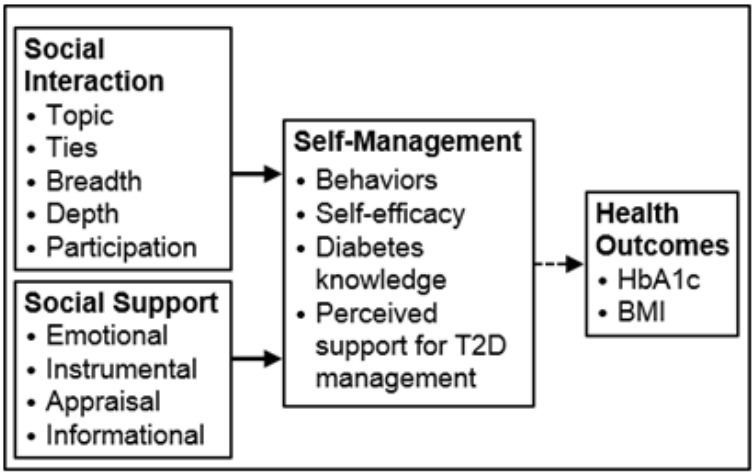
Individuals self-represent as avatars within these environments, a type of CME, to receive both informal and formal learning opportunities, thus reinforcing positive T2D self-management techniques [46,61,63]. Avatars, when high in *agency* (eg, accurate representation of a person in real life) and *behavioral realism* (eg, degree to which objects in the virtual environment act like they do in the real world), increase the involvement and engagement of individuals in the virtual environment [61]. This real-time interaction and support may positively influence self-management skills and behaviors. However, a gap in knowledge exists regarding the characteristics of social interaction and social support exchanged among adults living with diabetes that contribute to sustained behavior change and self-management [64,65].

Thus, this current study will provide insight into the depth, breadth, and quality of the social interaction and social support exchanged in a virtual environment through the study of conversations among participants in combination with survey responses, health outcomes (HbA1c, body mass index), and activity data. The parent study, Second Life Impacts Diabetes Education and Self-Management (SLIDES; 1R21-LM010727-01), provided self-management support and education in a virtual environment, where all voice, email, and text-chat conversations were recorded in real-time over a 6-month period [16]. The knowledge generated from this study will help determine what features are important to include in future T2D self-management interventions and how to best facilitate high-quality, effective support. Here we describe the theoretical and analytic approaches to this study exploring the characteristics of social interaction and social support exchanged among adults living with T2D who interacted in a virtual environment.

Theoretical Framework

This study uses Social Penetration Theory [66] and Strong/Weak Ties Theory [67,68] to guide this secondary analysis in order to gain an understanding of T2D-specific social interaction among providers and peers within a CME. These theories will help us examine the differences in interaction among both active and passive participants, amount and type of interaction, and exchange of social support, specifically centering on self-management of chronic illness. Figure 1 depicts the guiding framework for this study.

Figure 1. Guiding framework for this secondary analysis of qualitative and quantitative data from adults living with type 2 diabetes who interacted in a virtual environment. The bolded lines indicate the focus of this secondary analysis.



Social Interaction

Social Penetration Theory suggests that the perceived value of a relationship influences the perceived rewards of initiating and maintaining participation, which then influences the *breadth* (eg, number of topics discussed) and *depth* (eg, degree of intimacy and personalization of discussed topics). Thus, increased breadth and depth will occur in a high reward (eg, family member, valued and trusted friend) relationship; low breadth and depth will occur in relationships that are considered low reward (eg, casual acquaintance) [66,69]. The determination of the value in a relationship influences the tie strength between two individuals.

In Granovetter's [67] Strong/Weak Ties Theory, tie strength is time in which the relationship can develop and occur, intensity of emotions within that relationship, breadth and depth of intimacy, and whether the relationship is reciprocal and mutual. Strong and weak ties each serve a purpose. Strong ties provide support and intimacy, and weak ties provide linkages to information and resources outside of an individual's circle of intimate relationships [67-69]. The number and type of topics discussed within these ties, such as social support, have the potential to influence tie strength. Strong ties are defined by closeness of contact, duration of contact, frequency of contact, and a direct link between two individuals. In sum, strong ties are densely connected [67-69] and the amount of social support is high. For instance, strong ties are an individual's close family and friends with whom they frequently interact, and the ties are familiar with each other [68]. Weak ties are not densely connected, the relationships do not require large amounts of time or investment and can be formed more rapidly [67-69], and the amount and type of social support is lower than with strong ties. Weak ties are essential to a group; new information is diffused and shared between individuals [67-69]. An individual has weak ties with other people with whom they are not in frequent contact, and there is little familiarity among the individual's other weak ties [68]. The characterization of the ties between individuals is important, as well as the identification of when ties are integral and influential in self-management and the exchange of support.

Social Support

We conceptualize social support as emotional, instrumental, informational, and appraisal support [70-74]. Emotional support is the provision of empathy shared among peers and providers when discussing T2D self-management. Instrumental support is the provision of assistance or goods that assist in the self-management of T2D. Informational support is the sharing of knowledge that assists the individual in T2D self-management. Appraisal support includes affirmational comments among individuals regarding self-management actions taken [75]. Peer support (eg, support from peers living with T2D) consists of assistance in daily management, linkage to clinical care, and the ongoing availability of support [29].

Self-Management and Health Outcomes

In this study, we utilized the outcome measures from the parent study to conceptualize self-management and health outcomes [16,48]. Data collected included valid and reliable measurement of (1) self-management behaviors via the Summary of Diabetes Self-Care Activities [76], (2) diabetes knowledge via true/false items designed to assess diabetes knowledge [77], (3) perceived support for T2D management via the Diabetes Support Scale [78], (4) self-efficacy via the Diabetes Empowerment Scale-Short Form [79], (5) outcome data (HbA1c and body mass index) via medical chart reviews by the study coordinator, (6) demographics collected by the study coordinator, and (7) activity data (number of logins, time spent online) via participant activity in the SLIDES site [16,48]. These data were collected at baseline, 3 months, and 6 months and are described fully elsewhere [16,48].

Study Protocol

The overall goal of this study is to gain an understanding of T2D social interaction in a virtual environment, a type of CME, and the social support characteristics that increase and sustain self-management in adults living with this chronic illness. The specific aims for this study are:

- To describe the characteristics of social interaction using the following six *a priori* categories: (1) topics discussed, (2) strong/weak ties, (3) depth, (4) breadth, (5) participation, and (6) general engagement in the CME; and emergent codes that arise in a CME about self-management.
- To describe the characteristics of social support using the following four *a priori* categories: (1) emotional, (2) instrumental, (3) informational, and (4) appraisal; and emergent codes as they arise in a CME about self-management.
- To describe the trends of social interaction and social support over time, and the longitudinal relationship between social support and social interaction with SLIDES outcome data including self-management behaviors, self-efficacy, diabetes knowledge, perceived support for T2D management, health outcomes (HbA1c, body mass index), and participation (number of logins, time spent online).

Design

A mixed-methods secondary analysis of naturalistic, conversational, qualitative data (voice and text conversations) will be used to describe the characteristics of social interaction in a CME about self-management and support [80-82]. This secondary analysis was approved by the University Institutional Review Board (Pro00022132).

Parent Study

The SLIDES study looked at a virtual three-dimensional diabetes community that promoted knowledge application of self-management behaviors among adults with T2D [16,48]. The SLIDES sample included individuals living with T2D who self-represented as avatars (eg, representations of themselves) and interacted with peers while learning and practicing self-management skills. Individuals interacted in real-time self-management education and support classes focused on American Association of Diabetes Educators curriculum for self-management education and salient T2D self-management topics.

Participants

All participants (N=20) and providers (diabetes educators and study investigators) (N=4) of the SLIDES study, and all conversations among participants, will be used. No further recruitment of participants will occur, and no additional inclusion or exclusion criteria will be applied. The demographics and primary outcomes of this study have been previously reported elsewhere [16,48]. As we want to analyze the various ways that individuals participated, we will include all 20 participants knowing that some participated more actively than others. Passive and active participation are described in the operationalization of social interaction. This allows us to understand what is happening to those individuals who are more/less active and more/less passive. The qualitative conversation data have not been analyzed in the parent study.

Data Preparation

An Institutional Review Board approved transcriptionist and the first author transcribed the synchronous voice conversations. The first author verified concordance with the MP3 voice conversation files to ensure the accuracy of spoken words and the communication style of each participant. Each spoken word is linked to a SLIDES participant (de-identified), location of conversation in the SLIDES CME, and calendar date of conversation and is organized into a Microsoft Word file. Since the participants were provided a study-created screen name, their personal names were de-identified. These data were then organized by study week and uploaded into Atlas.ti for analysis.

Measures

Qualitative Data

These data include all synchronous voice conversations and asynchronous conversations (eg, text chat, discussion forums, and emails) over 6 months (1535 pages of transcribed text), thus providing secondary data for evaluating social interaction [16,48]. Table 2 provides the operationalization of social interaction [66-69,83] and social support [70-74] for this study. Conversations occurred in various contexts: participant to participant, participant to educator, discussion forums, and within group education and support sessions [16,48].

Quantitative Data

We will be using data that were previously collected and analyzed in the parent study [16,48]. Demographic data were collected on entry into the SLIDES study, and activity data were collected continuously when the participants entered the SLIDES site.

Data Analysis Plan

Overview

Table 3 provides a description of the analysis plan for the qualitative aims. The qualitative aims, characterizing social interaction and characterizing social support, will be first analyzed with content analysis [84] using Atlas.ti to manage and support the coding process.

Table 2. Operationalization of social interaction, social support, and source of support for this secondary analysis.

Variable	Operationalization in this study
Social interaction	Topic [83]: the content of the discussion about self-management, T2D, or living with chronic illness
	Ties (strong/weak) [67,68]: amount and duration of contact, intensity of emotions, reciprocity of interaction
	Depth [66,69]: degree of intimacy and personalization of discussed topics
	Breadth [66,69]: number of topics discussed
	Participation (active/passive): present and talking; present, not talking
Social support (4 categories as noted in the literature [70-74])	Emotional: exchange of feelings of trust, caring, love, belongingness, and warmth when discussing T2D self-management or behaviors
	Instrumental: exchange of tangible goods or services related to T2D self-management
	Informational: exchange of T2D-specific information among individuals
	Appraisal: exchange of praise for a T2D self-management behavior or action
	Emergent codes: to capture instances in the conversations not covered by the 4 categories of social support
Source of support (providers of support and/or education within the CME)	Provider: nurse practitioners, certified diabetes educator, principal investigator of SLIDES
	Peer: another individual with T2D

Table 3. Data analysis plan for the qualitative aims.

Aim and steps	Plan
Study Aim 1: Characterizing social interaction	To describe the characteristics of social interaction using six a priori categories: (1) topics discussed, (2) strong/weak ties, (3) depth, (4) breadth, (5) participation, (6) general engagement in the CME; and emergent codes that arise in a CME about self-management
Study Aim 2: Characterizing social support	To describe the characteristics of social support using the four a priori categories of social support: (1) emotional, (2) instrumental, (3) informational, and (4) appraisal; and emergent codes as they arise in a CME about self-management
Analysis Step 1: First level coding process (data-near coding process)	Determine appropriate coding unit for each a priori code
	Demographic coding (eg, conversation type, participant ID, participant study time, location in virtual environment, class type, conversation type)
	Code data:
	Social interaction: Use a priori codes (Table 1)
	Social support: Use a priori codes (Table 1)
	Team process: Code independently, gather together and debate definitions and coding, re-code documents following the meeting
Analysis Step 2: Second level coding process (increasing abstraction of codes)	When themes are created, create variables
	Create higher level, more abstract codes based on the first level codes: Social interaction and Social support
Team process: Same steps taken as in the first level coding process	

Table 4. Data analysis plan for the mixed-method aim.

Aim and steps	Plan
Study Aim 3: Mixed-methods aim	To describe the trends of social interaction and social support over time, and the longitudinal relationship between social support and social interaction with SLIDES outcome data including self-management behaviors, self-efficacy, diabetes knowledge, perceived support for T2D management, physiological data (HbA1c, body mass index), and activity data (number of logins, time spent online)
Analysis Step 3: mixing the data (identifying areas of convergence and divergence of these data)	Identify patterns that emerge that can be described with sample demographics (eg, race, duration of diabetes)

The codes and themes created using content analysis will be quantitized into numerical values in order to create code counts for use in displaying trajectory lines for the mixed-method aim [85,86]. Table 4 provides the analysis plan for the mixed-methods aim. Emergent codes will be identified in relation to observations of social support unique to participants living with T2D interacting in a CME. Codes will be analyzed consistent with the theoretical framework and in the context of social interaction, social support, and self-management of T2D. Thus, the theoretical framework provides the lens to examine the conversations with a more focused and guided analysis.

Validity and Rigor

We will use team coding procedures to ensure validity and reliability of findings and iteratively generate codes based on the theories [86,87]. We will ensure validity by providing rich descriptions of all codes with exemplar quotations, triangulating data from quantitative and qualitative sources, presenting any discrepant information identified during the coding process, and discussing all findings as a team [88]. Validity of findings is also strengthened due to the extensive time the first author (AAL) spent cleaning and organizing these data, the involvement of the last author (CMJ) who served as Principal Investigator of SLIDES, and the participation of the third author (AAV), a co-investigator in SLIDES who led the support sessions [88]. A codebook will be created that details creation of the codes and emerging themes and that contains an audit trail of actions throughout coding and analysis [89]. The coding team (AAL, RAA, CMJ) will meet regularly to ensure accuracy of coding, reliability, categorization, higher level code development, and emerging findings. The coding team will independently read and code 25% of the transcripts during the entire analysis to ensure reliability.

Qualitative Aims: First Level Coding

The coding team will initially independently code the transcripts using the a priori codes for 5% of the transcripts and then meet to discuss codes and coding units. The team will compare examples and findings and discuss results until agreement is reached on coding definitions and application of the definitions to these data. The coding team will look for coding agreement for the remaining 5% of cycles of coding. Due to the multidimensional structure that is anticipated to be present in the transcripts, no limit will be placed on the number of codes

to which a coding unit can be assigned. The coding team will repeat this process until we have agreement on the first level coding. Following discussions, the first author will re-code transcripts using any new codes, and the coding team will review work on a bi-weekly basis.

Qualitative Aims: Second Level Coding

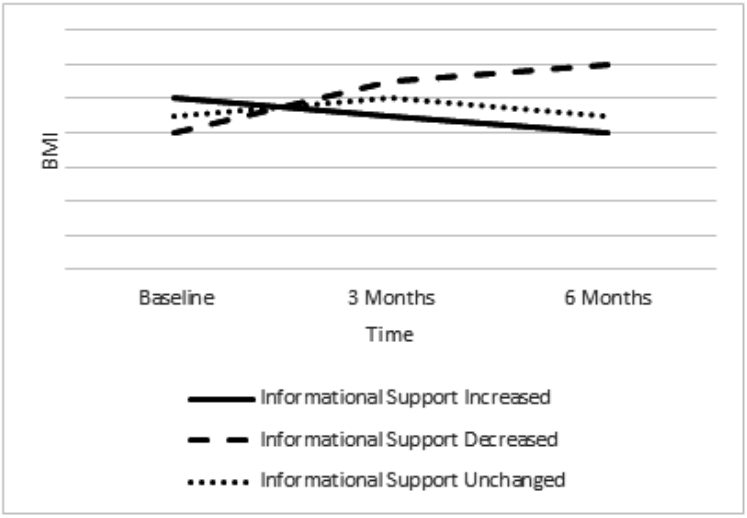
We will use data matrices to identify patterns in these data that emerge relating to social interaction and social support [90]. The coding team will meet to identify higher level and more refined codes, inclusive of the codes identified in first level coding. Second level coding will mirror the first level coding in that the coding team will independently code 5% of the transcripts and then meet to discuss emerging patterns in these data. No limit will be placed on the number of higher level codes that a coding unit can be assigned. These data, and the patterns identified, will be quantitized to variables related to social interaction and social support (eg, levels of depth, active listening) [85]. Descriptive statistics will be used to summarize differences, determine frequencies, and identify relationships.

Mixed-Methods Aim

The SAS program version 9.4 will be used to address this aim. Due to the small sample size (N=20), we will compute descriptive statistics only to summarize the characteristics of social interaction and social support. These data will then be used to examine the longitudinal relationship between these variables with body mass index and HbA1c. The variables created during analysis of these qualitative data for the social interaction and social support aims will be used in the analysis of the mixed-methods aim. These data will be first plotted on trajectory lines for each person for the social interaction and social support variables (eg, ties, emotional support), and two or three subgroups will be identified by visually examining their trends over time (eg, informational support increased, unchanged, or decreased). Then we will summarize the average trend for each variable created from qualitative data (eg, ties, emotional support) and overlay the SLIDES variables (eg, diabetes knowledge, self-efficacy) for the subgroups to identify the trajectories at three time points (ie, baseline, 3 months, 6 months) and relate these to body mass index and HbA1c. Figure 2 provides a sample of such graphs to visualize these data.

The visual and descriptive trajectory lines will allow us to overlay the average trends from the time points to describe trends over time and how social support and social interaction evolve. We will determine if there are differences in the trajectory plots described above, based on demographic factors, duration of diabetes, and time spent online.

Figure 2. Sample of graphs for Aim 3, the mixed-methods aim for BMI and time. We first visually categorize the 20 trajectories of informational support into increased, unchanged, and decreased groups. Here shows a plot of the three subgroup's BMI across the time points to see if the trajectories of BMI are correlated with the informational support: BMI decreased for the group of increased information support (filled line), BMI unchanged for the group of unchanged informational support (dotted line), and BMI increased for the group of decreased informational support (dashed line).



Discussion

Principal Considerations

Research indicates that sustained social support reinforces T2D self-management behaviors [7,29,91,92]. Current T2D social support research focuses on face-to-face interactions and CMEs with person-to-person interaction via the Internet [7,29,47-49,91,92]; yet, interventions for T2D over the past 15 years have not led to significant long-term improvements in self-management [49]. Therefore, a need exists for sustainable, innovative interventions that increase an individual's self-management behaviors by providing long-term contact with providers and peers that provide T2D specific support [93-95].

Type 2 diabetes self-management is positively influenced by sustained, continuous support via face-to-face or Internet environments [26,49]. Research shows that relationships formed in CMEs augment face-to-face support; however, specifics of these relationships remain unknown [96,97]. Thus, we do not have sufficient evidence for how to encourage and support effective interactions in CMEs. Sufficient knowledge about interaction in CMEs is needed as approximately 81% of all US

adults use the Internet and 72% look for health information online [98-100]. Thus, the analysis of verbatim, naturalistic conversations in a virtual environment, will characterize enacted, supportive interactions among individuals living with a chronic illness who are seeking information and support. Results from this study will provide a way to measure social support as it is provided in daily conversation and interaction to identify the real-time exchange of support among adults living with chronic illness.

The SLIDES platform allowed participants to have conversations online and exchange support in naturalistic conversations. Interactions in virtual environments are synchronous and include sight (eg, one can see graphics), sound (eg, one can hear other individuals talking and other ambient sounds in the environment), voice (eg, one can talk to others via a headset), text (eg, text-chatting with another person), and motion (eg, one can direct their avatar and navigate around the CME) [61,101]. This synchronous communication and the feelings of presence and co-presence mimic the real-time communication that occurs in relationships in the real world. Our belief is that conversational depth and breadth will occur in the virtual environment because individuals will feel like they are in the virtual environment (presence), with others (co-presence), and in a real-life conversation with another person and not an avatar (synchronous communication) [61]. Analysis of these naturalistic conversations will determine if the four categories of social support are reflected in social interactions in a CME. To our knowledge, this is the first study to analyze and characterize (1) social interaction among participants interacting in a T2D CME, in order to understand the nature of this kind of social interaction, and (2) social support in naturalistic conversations, in order to understand how to improve the exchange and delivery of social support in T2D specific interventions to populations with high rates of T2D. This data-rich sample allows for the identification of the nature of T2D-specific social support and social interaction in a CME using descriptive analysis and trajectory creation.

Limitations

Limitations of this study include the small sample size (N=20), having only one male participant, and the inability to probe individuals to clarify statements. These factors limit the generalizability of the findings, and thus findings will be interpreted with caution. However, a sample of this size will enable us to analyze the conversations among individuals in depth, so that we can fully understand the phenomenon of interaction in a CME [102]. The value of analyzing naturalistic conversations will aid in understanding the nature of social support and social interaction in a CME and its benefits for self-management. With these data, we hope to see instances of social support that are rich in personal narratives, describe living with T2D, and contain emotional connections with others.

Conclusions

The current study is unique because in the parent study, all interaction occurred within the virtual environment, which mimicked real life. The proposed study will determine the type of social support being exchanged in natural conversation through social interaction within a virtual environment by participants, and the subsequent changes in self-management. These results could be used to develop sustainable self-management interventions that promote high-frequency support. The proposed study will lead to further research to validate the findings in other populations. Subsequent research will aid in the development of effective and scalable self-management interventions that can reach large numbers of individuals including disadvantaged or diverse groups. The proposed study is a conceptual step in the development of self-management interventions aimed at improving population-level prevention and management of T2D, thus addressing the population burden and disparities seen with this chronic illness.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Resume and summary of discussion from the NIH-NINR grant review process.

[PDF File (Adobe PDF File), 359KB - resprot_v6i4e65_app1.pdf]

References

1. Centers for Disease Control and Prevention. Diabetes Report Card. Atlanta, GA: US Department of Health and Human Services; 2014. URL: https://www.cdc.gov/diabetes/pdfs/library/diabetesreportcard2014.pdf [accessed 2017-04-08] [WebCite Cache ID 6pa31PmNA]
2. Funnell M, Anderson M. Working toward the next generation of diabetes self-management education. Am J Prev Med 2002 May;22(4 Suppl):3-5. [Medline: 11985929]

3. Clark M. Diabetes self-management education: a review of published studies. Prim Care Diabetes 2008 Sep;2(3):113-120. [doi: 10.1016/j.pcd.2008.04.004] [Medline: 18779034]
4. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. N Engl J Med 1993 Sep 30;329(14):977-986. [doi: 10.1056/NEJM199309303291401] [Medline: 8366922]
5. Herrejon K, Hartke JL, Scherer J, Chapman-Novakofski K. The creation and impact evaluation of "Your guide to diet and diabetes," an interactive web-based diabetes tutorial. Diabetes Technol Ther 2009 Mar;11(3):171-179. [doi: 10.1089/dia.2008.0043] [Medline: 19216688]
6. Steinsbekk A, Rygg L, Lisulo M, Rise MB, Fretheim A. Group based diabetes self-management education compared to routine treatment for people with type 2 diabetes mellitus. A systematic review with meta-analysis. BMC Health Serv Res 2012 Jul 23;12:213 [FREE Full text] [doi: 10.1186/1472-6963-12-213] [Medline: 22824531]
7. Dale JR, Williams SM, Bowyer V. What is the effect of peer support on diabetes outcomes in adults? A systematic review. Diabet Med 2012 Nov;29(11):1361-1377. [doi: 10.1111/j.1464-5491.2012.03749.x] [Medline: 22804713]
8. Funnell MM, Anderson RM. Changing office practice and health care systems to facilitate diabetes self-management. Curr Diab Rep 2003 Apr;3(2):127-133. [Medline: 12728638]
9. Strom J, Egede LE. The impact of social support on outcomes in adult patients with type 2 diabetes: a systematic review. Curr Diab Rep 2012 Dec;12(6):769-781 [FREE Full text] [doi: 10.1007/s11892-012-0317-0] [Medline: 22949135]
10. Qi L, Liu Q, Qi X, Wu N, Tang W, Xiong H. Effectiveness of peer support for improving glycaemic control in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. BMC Public Health 2015 May 06;15:471 [FREE Full text] [doi: 10.1186/s12889-015-1798-y] [Medline: 25943398]
11. Nicolucci A, Kovacs Burns K, Holt RI, Comaschi M, Hermanns N, Ishii H, Dawn2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): cross-national benchmarking of diabetes-related psychosocial outcomes for people with diabetes. Diabet Med 2013 Jul;30(7):767-777. [doi: 10.1111/dme.12245] [Medline: 23711019]
12. Davison K, Pennebaker JW, Dickerson SS. Who talks? The social psychology of illness support groups. Am Psychol 2000 Feb;55(2):205-217. [Medline: 10717968]
13. Tang T, Ayala G, Cherrington A, Rana G. A review of volunteer-based peer support interventions in diabetes. Diabetes Spectrum 2011 May 16;24(2):85-98. [doi: 10.2337/diaspect.24.2.85]
14. American Diabetes Association. Diabetes Care. 2016. Standards of Medical Care in Diabetes URL: http://care.diabetesjournals.org/content/suppl/2015/12/21/39.Supplement_1.DC2/2016-Standards-of-Care.pdf [accessed 2017-04-08] [WebCite Cache ID 6paAwUrUd]
15. Tomky D, Cypress M, Dang D, Maryniuk M, Peyrot M, Mensing C. AADE Position Statement AADE7 Self-Care Behaviors. Diabetes Educator 2008;34(3):445-449. [doi: 10.1177/0145721708316625]
16. Johnson C, Feinglos M, Pereira K, Hassell N, Blascovich J, Nicollerat J, et al. Feasibility and preliminary effects of a virtual environment for adults with type 2 diabetes: pilot study. JMIR Res Protoc 2014 Apr 08;3(2):e23 [FREE Full text] [doi: 10.2196/resprot.3045] [Medline: 24713420]
17. Bretz R, Schmidbauer M. Media for interactive communication. Beverly Hills, CA: Sage Publications; 1983.
18. Bloomberg L, Meyers J, Braverman M. The importance of social interaction: A new perspective on social epidemiology, social risk factors, and health. Health Education & Behavior 1994 Dec 01;21(4):447-463. [doi: 10.1177/109019819402100407]
19. Lewinski A, Fisher EB. Social interaction in type 2 diabetes computer-mediated environments: How inherent features of the channels influence peer-to-peer interaction. Chronic Illn 2016 Jun;12(2):116-144. [doi: 10.1177/1742395315601414] [Medline: 26304692]
20. Johnson V, Lorig K. The internet diabetes self-management workshop for American Indians and Alaska Natives. Health Promot Pract 2011 Mar;12(2):261-270. [doi: 10.1177/1524839909335178] [Medline: 20534807]
21. Jennings A, Powell J, Armstrong N, Sturt J, Dale J. A virtual clinic for diabetes self-management: pilot study. J Med Internet Res 2009 Mar 30;11(1):e10 [FREE Full text] [doi: 10.2196/jmir.1111] [Medline: 21821504]
22. Clark CM. Peer support in diabetes management -- toward global application. Overview. Fam Pract 2010 Jun;27 Suppl 1:i3-i5. [doi: 10.1093/fampra/cmq001] [Medline: 20483800]
23. High A, Solomon D. Locating Computer-Mediated Social Support within Online Communication Environments. In: Webb L, Wright K, editors. Computer-Mediated Communication in Personal Relationships. New York: Peter Lang Publishing; 2011.
24. Riva G, Davide F, Ijsselsteijn WA. Being there: The experience of presence in mediated environments. In: Riva G, Davide F, Ijsselsteijn W, editors. Emerging communication: Studies in new technologies and practices in communication. Amsterdam: IOS Press; 2003:321.
25. Norris S, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. Diabetes Care 2001 Mar;24(3):561-587. [Medline: 11289485]
26. Norris S, Lau J, Smith SJ, Schmid CH, Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. Diabetes Care 2002 Jul;25(7):1159-1171. [Medline: 12087014]

27. Fisher E, Brownson CA, O'Toole ML, Anwuri VV. Ongoing follow-up and support for chronic disease management in the Robert Wood Johnson Foundation Diabetes Initiative. Diabetes Educ 2007 Jun;33 Suppl 6:201S-207S. [doi: 10.1177/0145721707304189] [Medline: 17620402]
28. Boothroyd R, Fisher EB. Peers for progress: promoting peer support for health around the world. Fam Pract 2010 Jun;27 Suppl 1:i62-i68. [doi: 10.1093/fampra/cmq017] [Medline: 20483801]
29. Fisher EB, Boothroyd RI, Coufal MM, Baumann LC, Mbanya JC, Rotheram-Borus MJ, et al. Peer support for self-management of diabetes improved outcomes in international settings. Health Aff (Millwood) 2012 Jan;31(1):130-139 [FREE Full text] [doi: 10.1377/hlthaff.2011.0914] [Medline: 22232103]
30. Caro J, Fisher EB. A solution might be within people with diabetes themselves. Fam Pract 2010 Jun;27 Suppl 1:i1-i2. [doi: 10.1093/fampra/cmn082] [Medline: 20483799]
31. Southwell B. Social Networks and Popular Understanding of Science and Health: Sharing Disparities. Baltimore, MD: Johns Hopkins University Press; 2013:1-152.
32. Greenhalgh T, Campbell-Richards D, Vijayaraghavan S, Collard A, Malik F, Griffin M, et al. New models of self-management education for minority ethnic groups: pilot randomized trial of a story-sharing intervention. J Health Serv Res Policy 2011 Jan;16(1):28-36. [doi: 10.1258/jhsrp.2010.009159] [Medline: 20739577]
33. Shaffer V, Zikmund-Fisher BJ. All stories are not alike: a purpose-, content-, and valence-based taxonomy of patient narratives in decision aids. Med Decis Making 2013 Jan;33(1):4-13. [doi: 10.1177/0272989X12463266] [Medline: 23065418]
34. Hinyard L, Kreuter MW. Using narrative communication as a tool for health behavior change: a conceptual, theoretical, and empirical overview. Health Educ Behav 2007 Oct;34(5):777-792. [doi: 10.1177/1090198106291963] [Medline: 17200094]
35. Berger CR. Goals and knowledge structures in social interaction. In: Daly JA, Knapp ML, editors. Handbook of interpersonal communication. Thousand Oaks, CA: SAGE Publications; 2002:181-212.
36. Graybeal A, Sexton JD, Pennebaker JW. The Role of Story-Making in Disclosure Writing: The Psychometrics of Narrative. Psychology & Health 2010 Oct 27;17(5):571-581. [doi: 10.1080/08870440290025786]
37. Pennebaker JW, Stone LD. Words of wisdom: language use over the life span. J Pers Soc Psychol 2003 Aug;85(2):291-301. [Medline: 12916571]
38. Greenhalgh T, Collard A, Campbell-Richards D, Vijayaraghavan S, Malik F, Morris J, et al. Storylines of self-management: narratives of people with diabetes from a multiethnic inner city population. J Health Serv Res Policy 2011 Jan;16(1):37-43. [doi: 10.1258/jhsrp.2010.009160] [Medline: 20819914]
39. Ames SC, Patten CA, Offord KP, Pennebaker JW, Croghan IT, Tri DM, et al. Expressive writing intervention for young adult cigarette smokers. J Clin Psychol 2005 Dec;61(12):1555-1570. [doi: 10.1002/jclp.20208] [Medline: 16193479]
40. Ramírez-Esparza N, Pennebaker JW. Do good stories produce good health?: Exploring words, language, and culture.: John Benjamins Publishing Company; 2006. URL: http://www.utpsyc.org/Nairan/research/health2.pdf [accessed 2017-04-13] [WebCite Cache ID 6ph93hBBQ]
41. Williams GC, Lynch M, Glasgow RE. Computer-assisted intervention improves patient-centered diabetes care by increasing autonomy support. Health Psychol 2007 Nov;26(6):728-734. [doi: 10.1037/0278-6133.26.6.728] [Medline: 18020845]
42. Yarnall KSH, Pollak KI, Østbye T, Krause KM, Michener JL. Primary care: is there enough time for prevention? Am J Public Health 2003 Apr;93(4):635-641. [Medline: 12660210]
43. Griffiths F, Lindenmeyer A, Powell J, Lowe P, Thorogood M. Why are health care interventions delivered over the internet? A systematic review of the published literature. J Med Internet Res 2006 Jun 23;8(2):e10 [FREE Full text] [doi: 10.2196/jmir.8.2.e10] [Medline: 16867965]
44. Stefanone M, Kwon KH, Lackaff D. Exploring the relationship between perceptions of social capital and enacted support online. J Comput-Mediat Comm 2012 Sep 13;17(4):451-466. [doi: 10.1111/j.1083-6101.2012.01585.x]
45. Pal K, Eastwood SV, Michie S, Farmer AJ, Barnard ML, Peacock R, et al. Computer-based diabetes self-management interventions for adults with type 2 diabetes mellitus. Cochrane Database Syst Rev 2013 Mar 28(3):CD008776. [doi: 10.1002/14651858.CD008776.pub2] [Medline: 23543567]
46. Burkow T, Vognild LK, Østengen G, Johnsen E, Risberg MJ, Bratvold A, et al. Internet-enabled pulmonary rehabilitation and diabetes education in group settings at home: a preliminary study of patient acceptability. BMC Med Inform Decis Mak 2013 Mar 05;13:33 [FREE Full text] [doi: 10.1186/1472-6947-13-33] [Medline: 23496829]
47. Ershow AG, Peterson CM, Riley WT, Rizzo AS, Wansink B. Virtual reality technologies for research and education in obesity and diabetes: research needs and opportunities. J Diabetes Sci Technol 2011 Mar 01;5(2):212-224 [FREE Full text] [doi: 10.1177/193229681100500202] [Medline: 21527084]
48. Johnson C, Feenan K, Setliff G, Pereira K, Hassell N, Beresford HF, et al. Building a Virtual Environment for Diabetes Self-Management Education and Support. Int J Virtual Communities Soc Netw 2013;5(3) [FREE Full text] [Medline: 25699133]
49. Pal K, Eastwood SV, Michie S, Farmer A, Barnard ML, Peacock R, et al. Computer-based interventions to improve self-management in adults with type 2 diabetes: a systematic review and meta-analysis. Diabetes Care 2014 Jun;37(6):1759-1766. [doi: 10.2337/dc13-1386] [Medline: 24855158]

50. Tang P, Overhage JM, Chan AS, Brown NL, Aghighi B, Entwistle MP, et al. Online disease management of diabetes: engaging and motivating patients online with enhanced resources-diabetes (EMPOWER-D), a randomized controlled trial. J Am Med Inform Assoc 2013 May 01;20(3):526-534 [FREE Full text] [doi: 10.1136/amiajnl-2012-001263] [Medline: 23171659]
51. McKay HG, Feil EG, Glasgow RE, Brown JE. Feasibility and use of an Internet support service for diabetes self-management. Diabetes Educ 1998;24(2):174-179. [doi: 10.1177/014572179802400207] [Medline: 9555356]
52. Mantovani F, Castelnuovo G, Gaggioli A, Riva G. Virtual reality training for health-care professionals. Cyberpsychol Behav 2003 Aug;6(4):389-395. [doi: 10.1089/109493103322278772] [Medline: 14511451]
53. Mantovani F. VR learning: potential and challenges for the use of 3D environments in education and training. In: Riva G, Galimberti C, editors. Towards CyberPsychology: Mind, Cognition and Society in the Internet Age. Amsterdam: IOS Press; 2001.
54. Yu CH, Parsons J, Mamdani M, Lebovic G, Shah BR, Bhattacharyya O, et al. Designing and evaluating a web-based self-management site for patients with type 2 diabetes--systematic website development and study protocol. BMC Med Inform Decis Mak 2012 Jun 24;12:57 [FREE Full text] [doi: 10.1186/1472-6947-12-57] [Medline: 22726578]
55. Gucciardi E, Demelo M, Offenheim A, Stewart DE. Factors contributing to attrition behavior in diabetes self-management programs: a mixed method approach. BMC Health Serv Res 2008 Feb 04;8:33 [FREE Full text] [doi: 10.1186/1472-6963-8-33] [Medline: 18248673]
56. Brown LL, Lustria ML, Rankins J. A review of web-assisted interventions for diabetes management: maximizing the potential for improving health outcomes. J Diabetes Sci Technol 2007 Nov;1(6):892-902 [FREE Full text] [doi: 10.1177/193229680700100615] [Medline: 19885163]
57. Funnell MM. The National Diabetes Education Program. Am J Nurs 2011 Dec;111(12):65-67. [doi: 10.1097/01.NAJ.0000408193.98005.2b] [Medline: 22112895]
58. Gary TL, Genkinger JM, Guallar E, Peyrot M, Brancati FL. Meta-analysis of randomized educational and behavioral interventions in type 2 diabetes. Diabetes Educ 2003;29(3):488-501. [doi: 10.1177/014572170302900313] [Medline: 12854339]
59. Behm-Morawitz E. Mirrored selves: The influence of self-presence in a virtual world on health, appearance, and well-being. Computers in Human Behavior 2013 Jan;29(1):119-128. [doi: 10.1016/j.chb.2012.07.023]
60. Schroeder R. Social interaction in virtual environments: Key issues, common themes, and a framework for research. In: Schroeder R, editor. The social life of avatars: presence and interaction in shared virtual environments. London: Springer; 2002:1-18.
61. Blascovich J. Social influence within immersive virtual environments. In: Schroeder R, editor. The social life of avatars: presence and interaction in shared virtual environments. London: Springer; 2002:127-145.
62. Lombard M, Ditton T. At the heart of it all: The concept of presence. J Comp Med Comm 1997;3(2):-. [doi: 10.1111/j.1083-6101.1997.tb00072.x]
63. Cook M. Design and initial evaluation of a virtual pediatric primary care clinic in Second Life(®). J Am Acad Nurse Pract 2012 Sep;24(9):521-527. [doi: 10.1111/j.1745-7599.2012.00729.x] [Medline: 22931477]
64. Fisher EB, La Greca AM, Greco P, Arfken C, Schneiderman N. Directive and nondirective social support in diabetes management. Int J Behav Med 1997;4(2):131-144. [doi: 10.1207/s15327558ijbm0402_3] [Medline: 16250735]
65. Green BL, Furrer CJ, McAllister CL. Does attachment style influence social support or the other way around? A longitudinal study of Early Head Start mothers. Attach Hum Dev 2011 Jan;13(1):27-47. [doi: 10.1080/14616734.2010.488121] [Medline: 21240693]
66. Altman I, Taylor D. Social Penetration: The Development of Interpersonal Relationships. New York: Holt, Rinehart and Winston; 1973.
67. Granovetter M. The strength of weak ties. Am J Soc 1973;78(6):1360-1380.
68. Granovetter M. The strength of weak ties: a network theory revisited. Sociological Theory 1983;1:201-233. [doi: 10.2307/202051]
69. Ballard-Reisch D, Rozzell B, Heldman L, Kamerer D. Microchannels and CMC: short paths to developing, maintaining, and dissolving relationships. In: Webb LM, Wright K, editors. Computer-Mediated Communication in Personal Relationships. New York: Peter Lang; 2011:56-75.
70. House J. Work stress and social support. Reading: Addison-Wesley Pub. Co; 1981.
71. Heaney C, Israel B. Social networks and social support. In: Glanz K, Rimer BK, Lewis FM, editors. Health behavior and health education: theory, research, and practice. San Francisco: Jossey-Bass; 2002:185-209.
72. Lakey B, Cohen S. Social support theory and measurement. In: Cohen S, Gordon L, Gottlieb B, editors. Social support measurement and intervention: a guide for health and social scientists. Oxford: Oxford University Press; 2000:29-52.
73. Langford C, Bowsher J, Maloney JP, Lillis PP. Social support: a conceptual analysis. J Adv Nurs 1997 Jan;25(1):95-100. [Medline: 9004016]
74. Vorderstrasse AA, Lewinski AA, Melkus G, Johnson CM. Social Support for Diabetes Self-Management via eHealth Interventions. Curr Diab Rep 2016 Dec;16(7):56. [doi: 10.1007/s11892-016-0756-0] [Medline: 27155606]

75. Heaney C, Israel B. Social Networks and Social Support. In: Glanz K, Rimer BK, Viswanath K, editors. Health behavior and health education: theory, research, and practice. San Francisco: Jossey-Bass; 2008:552.
76. Toobert D, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measure: results from 7 studies and a revised scale. Diabetes Care 2000 Jul;23(7):943-950 [FREE Full text] [Medline: 10895844]
77. Speight J, Bradley C. The ADKnowl: identifying knowledge deficits in diabetes care. Diabet Med 2001 Aug;18(8):626-633. [Medline: 11553199]
78. Barrera M, Glasgow RE, McKay HG, Boles SM, Feil EG. Do Internet-based support interventions change perceptions of social support?: An experimental trial of approaches for supporting diabetes self-management. Am J Community Psychol 2002 Oct;30(5):637-654. [doi: 10.1023/A:1016369114780] [Medline: 12188054]
79. Anderson R, Fitzgerald JT, Gruppen LD, Funnell MM, Oh MS. The Diabetes Empowerment Scale-Short Form (DES-SF). Diabetes Care 2003 May;26(5):1641-1642. [Medline: 12716841]
80. Heaton J. Secondary analysis of qualitative data: an overview. Historical Social Research 2008;33(3):33-45.
81. Vartanian T. Secondary Data Analysis. New York: Oxford University Press; 2011.
82. Boslaugh S. Secondary data sources for public health: a practical guide. Cambridge: Cambridge University Press; 2007.
83. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. PLoS Med 2010 Jul 27;7(7):e1000316 [FREE Full text] [doi: 10.1371/journal.pmed.1000316] [Medline: 20668659]
84. Krippendorff K. Content analysis: an introduction to its methodology. Thousand Oaks, Calif: Sage; 2004:413.
85. Sandelowski M, Voils C, Knafl G. On quantitizing. Journal of Mixed Methods Research 2009;3(3):208-222. [doi: 10.1177/1558689809334210]
86. Creswell J, Plano Clark V. Designing and Conducting Mixed Methods Research. Los Angeles: Sage Publications; 2011.
87. Krefting L. Rigor in qualitative research: the assessment of trustworthiness. Am J Occup Ther 1991 Mar;45(3):214-222. [Medline: 2031523]
88. Creswell J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Thousand Oaks, CA: Sage Publications; 2014:273.
89. Richards L, Morse JM. README FIRST for a User's Guide to Qualitative Methods. Thousand Oaks, CA: Sage Publications; 2007:288.
90. O'Cathain A, Murphy E, Nicholl J. Three techniques for integrating data in mixed methods studies. BMJ 2010 Sep 17;341:c4587. [Medline: 20851841]
91. Heisler M, Piette JD. “I help you, and you help me”: facilitated telephone peer support among patients with diabetes. Diabetes Educ 2005;31(6):869-879. [doi: 10.1177/0145721705283247] [Medline: 16288094]
92. Norris SL, Chowdhury FM, Van LK, Horsley T, Brownstein JN, Zhang X, et al. Effectiveness of community health workers in the care of persons with diabetes. Diabet Med 2006 May;23(5):544-556. [doi: 10.1111/j.1464-5491.2006.01845.x] [Medline: 16681564]
93. Vigersky RA. An overview of management issues in adult patients with type 2 diabetes mellitus. J Diabetes Sci Technol 2011 Mar 01;5(2):245-250 [FREE Full text] [doi: 10.1177/193229681100500207] [Medline: 21527089]
94. Holt RIG, Nicolucci A, Kovacs BK, Escalante M, Forbes A, Hermanns N, DAWN2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): cross-national comparisons on barriers and resources for optimal care--healthcare professional perspective. Diabet Med 2013 Jul;30(7):789-798. [doi: 10.1111/dme.12242] [Medline: 23710839]
95. Marrero D, Ard J, Delamater AM, Peragallo-Dittko V, Mayer-Davis EJ, Nwankwo R, et al. Twenty-first century behavioral medicine: a context for empowering clinicians and patients with diabetes: a consensus report. Diabetes Care 2013 Feb;36(2):463-470 [FREE Full text] [doi: 10.2337/dc12-2305] [Medline: 23349150]
96. Wright K, Muhtaseb A. Personal relationships and computer-mediated support groups. In: Wright K, Webb LM, editors. Computer-Mediated Communication in Personal Relationships. New York: Peter Lang; 2011:137-155.
97. Armstrong N, Koteyko N, Powell J. 'Oh dear, should I really be saying that on here?': issues of identity and authority in an online diabetes community. Health (London) 2012 Jul;16(4):347-365. [doi: 10.1177/1363459311425514] [Medline: 22067915]
98. Pew Internet & American Life Project Tracking Surveys 2014. 2014. Pew Internet and American Life Project: Trend Data (Adults) URL: http://pewinternet.org/Trend-Data-(Adults)/Online-Activites-Total.aspx [accessed 2017-04-08] [WebCite Cache ID 6paJW4Fp3]
99. Fox S, Duggan M. Pew Internet & American Life Project. Health online 2013 URL: http://www.pewinternet.org/2013/01/15/health-online-2013/ [accessed 2017-04-08] [WebCite Cache ID 6paJef4oY]
100. Boase J, Horrigan J, Wellman B, Rainie L. The Strength of Internet Ties: The Internet and Email Aid Users in Maintaining Their Social Networks and Provide Pathways to Help When People Face Big Decisions. 2006. URL: http://www.pewinternet.org/files/old-media/Files/Reports/2006/PIP_Internet_ties.pdf.pdf [accessed 2017-04-08] [WebCite Cache ID 6paJsskM5]
101. Blascovich J, Loomis J, Beall AC, Swinth KR, Hoyt CL, Bailenson JN. Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology. Psychological Inquiry 2002 Apr;13(2):103-124. [doi: 10.1207/S15327965PLI1302_01]

102. Sandelowski M. Sample size in qualitative research. Res. Nurs. Health 1995 Apr;18(2):179-183. [doi: 10.1002/nur.4770180211]

Abbreviations

CME: computer-mediated environment
HbA1c: glycosylated hemoglobin
SLIDES: Second Life Impacts Diabetes Education and Self-Management (1R21-LM010727-01)
T2D: type 2 diabetes

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Protocol

Engaging Patients and Caregivers Managing Rare Diseases to Improve the Methods of Clinical Guideline Development: A Research Protocol

Dmitry Khodyakov[1], PhD; Kathi Kinnett[2], MSN, CNP; Sean Grant[1], DPhil; Ann Lucas[2], MS; Ann Martin[2], MS; Brian Denger[2]; Holly Peay[3], PhD; Ian Coulter[4], PhD; Arlene Fink[5], PhD

[1]RAND Health, Santa Monica, CA, United States

[2]Parent Project Muscular Dystrophy, Hackensack, NJ, United States

[3]RTI International, Research Triangle Park, NC, United States

[4]RAND, Santa Monica, CA, United States

[5]University of California Los Angeles, Los Angeles, CA, United States

Corresponding Author:
Dmitry Khodyakov, PhD
RAND Health
RAND Corporation
1776 Main Street, PO Box 2138
Santa Monica, CA,
United States
Phone: 1 310 393 0411 ext 6159
Fax: 1 310 260 8175
Email: dmitry_khodyakov@rand.org

Abstract

Background: Clinical guidelines provide systematically developed recommendations for deciding on appropriate health care options for specific conditions and clinical circumstances. Up until recently, patients and caregivers have rarely been included in the process of developing care guidelines.

Objective: This project will develop and test a new online method for including patients and their caregivers in this process using Duchenne muscular dystrophy (DMD) care guidelines as an example. The new method will mirror and complement the RAND/UCLA Appropriateness Method (RAM)—the gold standard approach for conducting clinical expert panels that uses a modified Delphi format. RAM is often used in clinical guideline development to determine care appropriateness and necessity in situations where existing clinical evidence is uncertain, weak, or unavailable.

Methods: To develop the new method for engaging patients and their caregivers in guideline development, we will first conduct interviews with experts on RAM, guideline development, patient engagement, and patient-centeredness and engage with Duchenne patients and caregivers to identify how RAM should be modified for the purposes of patient engagement and what rating criteria should patients and caregivers use to provide their input during the process of guideline development. Once the new method is piloted, we will test it by conducting two concurrently run patient/caregiver panels that will rate patient-centeredness of a subset of DMD care management recommendations already deemed clinically appropriate and necessary. The ExpertLens™ system—a previously evaluated online modified Delphi system that combines two rounds of rating with a round of feedback and moderated online discussions—will be used to conduct these panels. In addition to developing and testing the new engagement method, we will work with the members of our project's Advisory Board to generate a list of best practices for enhancing the level of patient and caregiver involvement in the guideline development process. We will solicit input on these best practice from Duchenne patients, caregivers, and clinicians by conducting a series of round-table discussions and making a presentation at an annual conference on Duchenne.

Results: The study protocol was reviewed by RAND's Human Subjects Protection Committee, which determined it to be exempt from review. Interviews with RAM experts have been completed. The projected study completion date is May 2020.

Conclusions: We expect that the new method will make it easier to engage large numbers of patients and caregivers in the process of guideline development in a rigorous and culturally appropriate manner that is consistent with the way clinicians

participate in guideline development. Moreover, this project will develop best practices that could help involve patients and caregivers in the clinical guideline development process in other clinical areas, thereby facilitating the work of guideline developers.

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KEYWORDS

Delphi method; Duchenne muscular dystrophy; ExpertLens; guideline development; online stakeholder engagement panels; patient engagement

Introduction

Clinical guidelines provide systematically developed recommendations for deciding on appropriate health care options for specific conditions and clinical circumstances [1]. A key methodological aspect that influences the quality of guideline recommendations is the composition of the group developing the guideline [2]. All stakeholders with a legitimate interest in a clinical guideline should be engaged in guideline development to ensure that guidelines are created in a transparent, democratic manner and are acceptable to different stakeholder groups [3]. However, clinical guideline development groups traditionally have not directly involved patients or their caregivers [4]. For example, only an estimated 25% of guidelines involve patients in the development process [4]. Moreover, a review of 51 evidence-based clinical practice guidelines found only 5% of guideline word count and 6% of references were related to patient preferences [5].

Patients, their caregivers, and many organizations concerned about guideline development have long argued that guideline development groups need to better include patients and caregivers because these stakeholders have particular knowledge and expertise on the direct experience of conditions of interest [1]. Research shows that patients and clinicians value the balance between risks and benefits differently [6] and that patients and their families provide unique perspectives that may differ from areas of focus in a clinical encounter [7]. For instance, while some care recommendations might be deemed appropriate and necessary by clinicians, they may not be acceptable from the patient perspective [8]; patients may focus more on issues related to overall quality of life rather than specific disease areas or life expectancy [9]. Effective implementation of guidelines ultimately requires patient adherence, and one might argue that the practical use of guidelines will be higher where patients feel the guidelines are sensitive and relevant to their needs. Moreover, the World Health Organization, National Institute for Health and Care Excellence (NICE), and Institute of Medicine also called for involving patients and other public stakeholders in developing and implementing clinical guidelines [4,8,10]. For example, the Guideline International Network (G-I-N)—an international organization dedicated to guidelines and to hosting the largest international guideline library—created a Patient and Public Involvement Group (G-I-N PUBLIC) to more effectively engage patient stakeholders in developing and implementing clinical guidelines [11]. Finally, the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach to guideline development also encourages guideline developers to ensure that guidelines address the outcomes that patients value and that their recommendations are likely to be acceptable from the patient perspective [12].

While there is agreement that patients should be involved in guideline development, there is no consensus on how patients should participate in this process. Patients can be involved at different stages of the process, from topic selection, to reviewing and grading the strength of evidence, to developing recommendations [13]. They can also be asked to provide their views on living with their condition, accessing services, perceived benefits and harms of treatment options, or clinical outcomes of importance [1,14]. Perhaps more than any other stakeholder, patients are able to reflect on what outcomes they are looking for from the guidelines. Besides asking patients to join the evidence review group [15] or to submit evidence to be considered for guideline development [1], which could lead to a broader range of evidence being considered, guideline development groups have engaged patients in reviewing existing studies on patient preferences and solicited patient input in designing data collection instruments to help identify areas where patients and their caregivers feel guideline recommendations are most needed [16]. Some guideline groups have dedicated time during meetings to focus on patient and caregiver perspectives [17]. For example, NICE uses deliberative participation methods that involve members of the general public, including patients, in discussing social values related to clinical guideline development, so panel experts can interact directly with citizens [18]. Some guideline organizations include professional advocates acting on behalf of patients with a given condition in guideline development groups or panels to promote "the patient perspective" as an influence on guideline recommendations [19]. Although professional patient advocates play an important role, lay people with a given medical condition should also be directly engaged in the process of developing guideline recommendations [20] because when they are excluded, trade-offs on what makes the cut as a recommendation are made on behalf of patients rather than with and by patients [21]. Finally, it is generally not possible for one person or a small number of people to adequately represent the diversity of perspectives of all patients with the condition. Therefore, approaches that encourage participation of larger groups of patients are needed.

In summary, research is needed to develop a systematic, scalable, and culturally appropriate method to engage patients—particularly those with rare diseases or disabilities that limit their mobility—and their caregivers in developing guideline recommendations. Ideally, this method should facilitate the practical use of care guidelines given low levels of compliance and adherence to care recommendations among both clinicians and patients [22,23]. Finally, this new method

should be consistent with the method used by clinicians in the process of developing consensus-based clinical guidelines and account for key recommendations from a workshop of international leaders in guideline development that recommended to expand patient engagement methods to include Web-based consultations and to analyze the benefits and drawbacks of specific methods for patient involvement [13].

In this project, we will develop such a method using Duchenne muscular dystrophy (DMD) as an example. DMD is a progressive, fatal disorder where caregiving, financial, emotional, and physical demands increase over time and can impact the entire family. Affected individuals have progressive loss of functional muscle fibers, which results in weakness, loss of ambulation (typically in the teen years), and premature death (typically in the mid-to-late second decade of life) [24]. The DMD community developed a set of clinical care guidelines covering 8 domains of care [25,26], but patients and caregivers have been consulted in the development of guidelines for 2 domains only.

Methods

Overview

This project is an equal partnership between researchers from RAND, a nonprofit research institution that developed Delphi and RAND/UCLA Appropriateness Method (RAM), and community partners from Parent Project Muscular Dystrophy (PPMD), the largest most comprehensive nonprofit organization in the United States focused on finding a cure for DMD. The partnership is a natural fit given the complementary expertise, skills, and resources both organizations bring to the partnership. We assembled a strong interdisciplinary team of academic and community investigators, along with patient and caregiver representatives, who bring the right mix of methodological skills and clinical expertise combined with the lived experience of caring for a Duchenne patient. The project has a 7-person interdisciplinary Advisory Board that includes an adult DMD patient, caregivers and patient advocates, researchers, a clinician, a guideline developer, and a RAM expert.

Data Collection

Our study relies on a 3-step mixed-methods approach to develop and test a new approach for patient engagement in clinical guideline development.

First, we will adapt RAM, a gold standard approach used by clinical experts in the process of guideline development to reach consensus on appropriateness and necessity of care recommendations [27], for the purposes of systematic online engagement of DMD patients and their caregivers in the process of determining patient-centeredness of already existing care guidelines. RAM is a modified Delphi method that combines two rating rounds with a face-to-face moderated discussion. Nine clinical experts review the existing evidence (if any) and rate the appropriateness and sometimes necessity of existing treatment options or procedures using a 9-point Likert scale. Appropriateness and necessity ratings are based on experts' own clinical judgments—informed by the systematic review of existing evidence—about what treatment options are best for "an average patient presenting to an average physician who performs the procedure in an average hospital" [27]. RAM is considered a formal consensus exploration method that meets the requirements of a scientific method; it has been recommended for use in guideline development in the absence of rigorously conducted randomized controlled trials [28] because it helps provide explicit links between the scientific evidence and the guideline recommendation. RAM was used to develop Duchenne guidelines. RAM panels, however, have been criticized for their small size and inclusion of only clinicians and researchers [29].

In modifying RAM, we will consult with up to 10 researchers and clinicians who have used RAM in the past, engaged patients in guideline development, or worked on topics related to patient-centeredness. We will solicit their perspectives on what modifications to RAM are needed to facilitate patient and caregiver engagement in guideline development, how patient-centeredness ratings of care management strategies can be included in guidelines, how guidelines can be rated and perceived by the clinical community, and how these ratings could help providers, patients, and their caregivers determine the best course of action and ensure adherence to care recommendations.

To triangulate these findings, we will also solicit input from a maximum variation purposive sample of up to 10 adult DMD patients and up to 30 caregivers. We can achieve diversity of perspectives and experiences by recruiting adult patients and caregivers of patients at various stages of disease progression, which is typically associated with the patient's age, and from different geographic locations. Participants will be recruited by PPMD through its Duchenne Connect (DCN) registry—the largest repository of patient self-reported information on DMD.

We will be asking patients and caregivers to share their perspectives on the topics covered during the RAM expert interviews and comment on the usability of and suggest modifications to the ExpertLens (EL) system, an online modified Delphi platform that we will use for patient and caregiver engagement. EL is a previously evaluated online modified Delphi system that typically combines two rounds of rating with a round of asynchronous moderated online discussions [30,31]. EL has been used in numerous research studies [32-39] but has yet to be used in the context of patient involvement in clinical guideline development. We chose EL because it allows for conducting RAM panels and soliciting input from large, diverse, and geographically distributed groups of participants iteratively; for combining quantitative and qualitative data; for engaging participants anonymously; and for exploring points of agreement and disagreement among participants [40,41]. These characteristics make EL particularly useful for engaging DMD patients and caregivers—who are located around the country, with some living abroad—and for collecting their input on existing care guidelines for DMD. Patients and caregivers will rate patient-centeredness of care recommendations using 9-point Likert scales and share their thoughts using online discussion boards that use the same open-ended format as previous PPMD engagement efforts.

To learn what DMD patients and their caregivers think about EL, we will first ask them to watch a short video describing each EL round and what participation in the panel will entail. We will then provide them with access to the EL system and ask them to share their thoughts on the user-friendliness of the EL tool, the instructions on how to use EL, the statistical feedback that will be provided to participants, and the interactiveness of the discussion round, among other topics. To do this, participants will answer a series of open-ended questions and join threaded discussion boards within EL. We will also ask questions about participants' understanding of and thoughts about patient-centeredness, participation burden in the EL process that is likely to be acceptable from the perspective of patients and caregivers, the maximum number of clinical scenarios, and the amount and type of background information on DMD patient and caregiver preferences and clinical information that should be included. We anticipate that participants will spend approximately 1 to 2 hours answering these questions and engaging in an online discussion over a period of 7 to 10 days. They will receive a $50 gift card for their participation.

Based on the input obtained from expert interviews and DMD patients and caregivers, we will implement changes to the EL platform and develop the modified Delphi protocol for rating patient-centeredness of already developed clinical guidelines. The revised version of the EL will be pilot tested by 2 to 3 DMD patients and 7 to 8 caregivers, who will go through all three rounds of the EL process as if they were real study participants. After each round, pilot-testers will share feedback by answering questions either by email or phone. These open-ended questions will focus on specific issues related to system usability, question clarity, and ease of discussion use, among other topics. We anticipate that participation in all three rounds will take about 3 to 4 hours over a period of 3 weeks. Participants will receive a $50 gift card for each round completed at the end of the pilot.

Second, we will test the new approach using one of the DMD care guideline domains that was developed using RAM but without patient or caregiver input, such as cardiac or endocrine care management guidelines. To do so, we will conduct two 3-round EL panels using a modified version of the EL system to determine the level of patient-centeredness of selected DMD care recommendations already deemed clinically appropriate. Our operational definition of patient-centeredness will be informed by the existing literature and consistent with the operationalization of appropriateness used in RAM. Our 3-round design is consistent with a recommendation for conducting Delphi studies with 2 or 3 rating rounds [42]. In testing the new approach, we will compare participants' ratings of patient-centeredness, satisfaction levels, and participation rates after rounds 1 and 3 in both panels. Because round 1 of the EL process is essentially a survey, we will treat round 1 ratings as data from a patient engagement survey—a more common mode of patient engagement than the modified Delphi approach [43]. Such a strategy is particularly relevant for comparing the two approaches in a rare disease community where the pool of potential participants is limited. Finally, as in previous studies validating the EL approach [31,39], we will determine the replicability of final panel ratings of patient-centeredness by comparing results of two EL panels conducted using the same protocol.

We will use the DCN patient registry and PPMD social media channels to recruit 20 to 25 adult patients and 60 to 70 caregivers with a range of experiences with Duchenne care and varying degrees of comfort using technology. We will then randomly assign them to two panels similar in their composition. Doing so will help us determine the replicability of panel determinations and adhere to the best practice of conducting online modified Delphi panels that suggests including 20 to 40 participants [31] to ensure their active participation while minimizing burden associated with reading comments posted by all panel members. We will recruit more than 40 participants per panel to account for attrition typical for multiround Delphi studies without face-to-face meetings. Our panels will be significantly larger than a traditional 9-person RAM clinical panel [27]. We can engage more participants because of the online nature of the panel, which helps increase the reliability of panel findings [28]. Our goal is to recruit a maximum variation sample [44] that reflects the diversity of DMD patient and caregiver experiences. This sample will not be random, because participants will be chosen on purpose to ensure their knowledge, expertise, and diversity of experiences. This is a standard approach to recruiting Delphi participants [28,45].

In round 1, participants will use 9-point Likert scales to rate the level of patient-centeredness of selected care management strategies and explain their responses using open-text boxes provided after each rating question (Figure 1). In round 2, participants will see a distribution of responses to all round 1 questions (Figure 2). While only the panelist knows his or her individual rating, all participants know the group's ratings. Showing statistical feedback to the participant is an essential component of the Delphi process [42]. For each question, participants will see a bar chart showing the frequency of each response category (yellow bars), a group median (blue line), their individual response (red dot), and a short statement describing the group decision based on the group agreement as produced by the RAM [27]. Consistent with best practices in Delphi studies [45], we will provide instructions on how to interpret statistical results using instructional videos and text boxes that appear when a participant hovers over a chart. Participants will be also able to review all rationale comments posted in round 1 and discuss group ratings using an asynchronous and anonymous discussion board moderated by content experts from PPMD/DCN and online engagement experts from RAND. In round 3, participants will reanswer round 1 questions and rate any new care management strategies that might have been suggested in round 2. Allowing for new questions to be added in round 3 is consistent with the best practices for conducting Delphi studies [42]. All participants will receive a $50 gift card for completing each round.

At the end of each EL panel, participants will use 7-point Likert-type scales to rate their satisfaction with the online engagement process [31] by expressing their level of agreement with such statements as "participation in this study was interesting," "the discussions brought out views I hadn't considered," and "I was comfortable expressing my views in the discussion round," among others. We will use a modified

version of these questions after round 1 and 3 to compare participants' experiences. Modifications to satisfaction questions that are asked after round 1 are needed because participants would not have participated in the discussion round at that time. We will develop additional questions about the usefulness and feasibility of widespread use of the online process of rating patient-centeredness of care guidelines. Open-ended questions will be added to encourage participants to use their own words to share their experiences and perspectives. A subsample of patients and caregivers involved in the EL process will be asked to participate in semistructured phone interviews to further share their experiences and thoughts after they complete all study rounds.

Third, we will develop a series of best practices for engaging patients and their caregivers in the process of care guideline development. To do so, we will identify generalizable lessons learned that could inform the methodology of engaging patients and caregivers in the process of guideline development by working in close collaboration with our study Advisory Board. We will share these best practices during one of the PPMD's annual Connect Conferences that are attended by nearly 500 families from around the world. During the conference, we will engage with adult DMD patients, caregivers, and clinicians in a series of up to three round-table discussions that will allow us to discuss how to address care management approaches deemed appropriate but not consistent with patient's care preferences or desired outcomes (eg, not patient-centered). Such small group discussions are a core component of the community-partnered research conference model that we developed for ensuring appropriate dissemination of study findings and for soliciting community input on study outcomes [46]. Each round-table discussion will last for about 60 to 90 minutes and include up to 8 participants. As a token of appreciation, participants will receive a $50 gift card.

Figure 1. Round 1 mock-up screenshot.

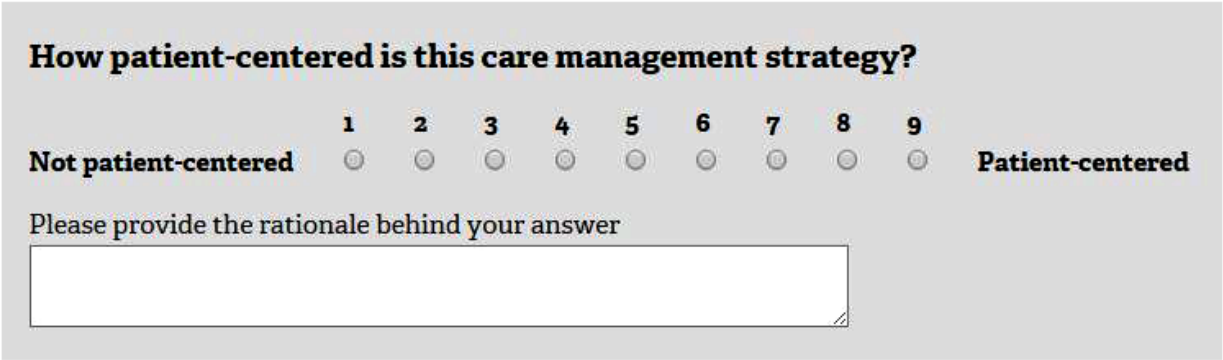
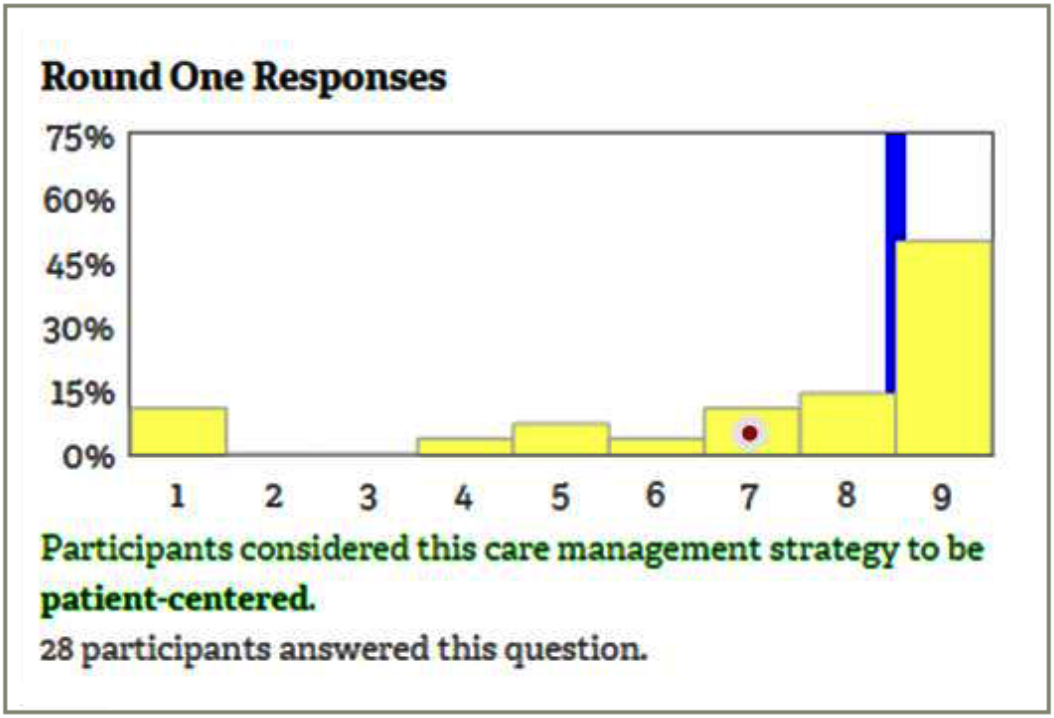


Figure 2. Round 2 mock-up screenshot.



Data Analysis

There are two types of data analysis that will be performed in this study. First, qualitative data from expert and EL participant interviews; feedback from pilot testers about EL; responses to all open-ended questions, rationale comments, and discussions within EL; and round-table discussions will be analyzed thematically by identifying and describing explicit and implicit ideas in the data. Applied thematic analysis [47] will be used because it helps reduce large amounts of textual data and present them in easy-to-understand statements that could be used to explain how experts feel about patient engagement in guideline development, how the EL system should be modified to facilitate patient engagement in care guideline development, how patient input should be solicited, and what participants think about an online approach to patient and caregiver engagement in guideline development once they participate in the study. To expedite the data analysis and ensure its usefulness, we will begin with a deductive approach to directly answer our research questions. At the same time, we will use an open coding strategy to flag interesting ideas and themes that may not be directly relevant to research questions but should be explored further once preliminary data analysis is complete or once more data have been analyzed [48]. Such an inductive approach is crucial for identifying unanticipated ideas and issues that frequently emerge from open-ended questions.

Given the volume of data collected from different types of participants, we will ensure efficient data management by using qualitative data analysis (QDA) software such as MAXQDA (Verbi GmbH) to code and retrieve large amount of textual data to help ensure analysis rigor [49]. Doing so will help us organize, evaluate, code, annotate, and interpret qualitative data by creating easy-to-read reports and data visualizations. We will develop, program within the QDA software, and update on an as-needed basis a codebook—a list of codes, often hierarchically organized, accompanied by a description and examples of each code—to facilitate data coding. Data coders will be trained on how to use the codebook, work jointly to code approximately 20 percent of the data, and discuss any discrepancies until consensus is achieved and the codebook is appropriately adjusted.

Second, ratings of patient-centeredness collected during the EL panel process will be analyzed quantitatively to determine the existence of consensus among participants. It is recommended that every Delphi study determine how consensus will be defined among participants before the data collection begins [42]. One of the EL features is its use of the RAM [27] to automatically determine the group decision (eg, whether a particular care management strategy was deemed patient-centered) for each round 1 item, which is displayed in round 2 and is also calculated after round 3. This process, identical to that used in determining appropriateness of different DMD care management strategies, begins with determining the existence of disagreement among participants using the following a priori process. EL automatically (1) calculates the value of interpercentile range (IPR), or the range of responses that fall between the 70th and the 30th percentiles; (2) calculates the value of the interpercentile range adjusted for symmetry (IPRAS), which is a measure of dispersion for asymmetric distributions; and (3) compares the values of IPR and IPRAS to see if there is disagreement. Disagreement is said to exist if IPR>IPRAS [27,50]. Disagreement among participants automatically produces an uncertain decision. If, instead, there is no disagreement among panelists, the value of the median will determine if the group decision is positive, negative, or uncertain. If the median is within the upper tertile of the 9-point response scale (response categories 7-9), then the decision is positive, meaning that a care management approach is considered to be patient-centered. If the median is within the lower tertile of the 9-point response scale (response categories 1-3), then the decision is negative, meaning that a care management approach is considered to be not patient-centered. A median that lies within the middle tertile (response categories 4-6) produces an uncertain decision. We will use this approach to determining consensus on the patient-centeredness of care management strategies in both EL panels using round 1 and round 3 rating data.

To compare survey and modified Delphi results, we will pool the data across two EL panels and compare determinations of patient-centeredness after round 1 (survey) and round 3 (Delphi). Because there is no right or wrong response, it is not possible to determine which approach produces better results or is more valid at the time the data are collected. However, we follow a recommended practice in Delphi studies and focus on how much each method can help patients and their caregivers reach consensus [28]. To do so, we will first calculate the percentage of care management strategies for which panelists reached agreement versus those where agreement was not achieved. We will then focus on strategies where panelists reached agreement and calculate the proportion with positive, negative, and uncertain determinations. Our assumption is that there will be fewer strategies characterized by participant disagreement after round 3, which we treat as an indicator of the benefit of using the modified Delphi approach. Still, we believe the survey approach may have its own benefit. Indeed, we assume that participant attrition rates (eg, the number of nonresponders) will be smaller in round 1 than in round 3. Larger samples may help provide a better description of the diversity of patient experiences, albeit with potentially fewer qualitative details that will crystalize after round 2 discussion.

To determine the replicability of online panel ratings, we will adopt the following a priori analytic approach originally developed by Shekelle and colleagues [51] to analyze reproducibility of in-person panel ratings. We will first examine round 3 determinations of patient-centeredness for each care management strategy and identify the proportion of strategies receiving positive, negative, or uncertain determinations. Then, we will determine the pairwise percentage of agreement between the two panels and use *t* tests to identify any statistically significant differences in panel ratings. Because the distribution of ratings may be nonnormal, we will conduct sensitivity analyses using the Wilcoxon rank sum, a nonparametric method. We will treat a 70% agreement as an indicator of acceptable reproducibility, which is at least as good as that of in in-person panels [51]. Finally, we will calculate kappa coefficients comparing the determinations made by the two panels across items. If the kappa statistic is at least moderate (.41-.60), we

will consider the online approach to be a reliable mode of collecting patient-centeredness ratings using the modified RAM approach [52]. This threshold is conservative; previous research shows that the reproducibility of both in-person [51] and online [31] panel findings is rarely better than moderate.

Besides comparing ratings of patient-centeredness, we will also focus on participant experiences after round 1 (survey) and round 3 (Delphi). As in earlier studies [31], we will pool the data across the two EL panels and look at the average response to each satisfaction question asked in round 1 and round 3. We will consider a mean value of 5 (agree slightly) and higher on the 7-point positively worded agreement scale to be an indicator of a generally positive opinion. Depending on sample size, we may conduct exploratory factor analyses to identify constructs that capture participant experiences and opinions about the new online system. To explore differences in participant satisfaction and perceived usefulness of the online approach after rounds 1 and 3, we will use a paired *t* test. We anticipate greater satisfaction and perceived usefulness after round 3 but a higher level of perceived participation burden.

Results

The study protocol was reviewed by RAND's Human Subjects Protection Committee, which determined it to be exempt from review. Interviews with RAM experts have been completed. The study team is in the process of analyzing these interviews. The projected study completion date is May 2020.

Discussion

Our study is expected to make a number of significant methodological contributions to a growing body of approaches to integrate patients and caregivers as active participants in research teams and decision-making bodies. First, by adapting an existing gold standard approach to expert elicitation for the purposes of systematic engagement of patients and caregivers in a culturally appropriate yet scientifically rigorous manner, our study will help address a methodological gap in evidence on consumer involvement and systematic integration of patient preferences in clinical practice guidelines [4,43]. Second, the proposed project augments and complements efforts to update the existing care and management guidelines for DMD, led by the Centers for Disease Control and Prevention's DMD Care Considerations Working Group. In the proposed project, we will introduce an innovative new step that could be integrated into care guideline development where patients and their caregivers will rate DMD care management strategies already deemed clinically appropriate and necessary on the patient-centeredness criteria that will be developed in close partnership between patients, clinicians, and researchers. Doing so may help mitigate barriers that have led to variability in guideline implementation and increase guideline adherence, which may lead to improved treatment and quality of life for affected patients and families. Third, the proposed project will develop best practices that could help involve patients and caregivers in the clinical guideline development process in other clinical areas, thereby facilitating the work of groups aiming to incorporate patient values and preferences into guideline development, such as G-I-N and GRADE.

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Conflicts of Interest

DK and SG are members of the ExpertLens team at RAND. SG's spouse is a salaried employee of Eli Lilly and Company and owns stock. SG has accompanied his spouse on company-sponsored travel. All other coauthors report no conflicts of interest.

References

1. Kelson M. Patient involvement in clinical guideline development. Where are we now? J Clin Gov 2001;9:169-174.
2. Grimshaw J, Eccles M, Russell I. Developing clinically valid practice guidelines. J Eval Clin Pract 1995 Sep;1(1):37-48. [Medline: 9238556]
3. Cluzeau F, Wedzicha JA, Kelson M, Corn J, Kunz R, Walsh J, ATS/ERS Ad Hoc Committee on Integrating and Coordinating Efforts in COPD Guideline Development. Stakeholder involvement: how to do it right: article 9 in Integrating and coordinating efforts in COPD guideline development. An official ATS/ERS workshop report. Proc Am Thorac Soc 2012 Dec;9(5):269-273. [doi: 10.1513/pats.201208-062ST] [Medline: 23256170]
4. Schünemann HJ, Fretheim A, Oxman AD. Improving the use of research evidence in guideline development: 10. Integrating values and consumer involvement. Health Res Policy Syst 2006 Dec 05;4:22 [FREE Full text] [doi: 10.1186/1478-4505-4-22] [Medline: 17147811]
5. Chong C, Chen I, Naglie C, Krahn M. Do clinical practice guidelines incorporate evidence on patient preferences? Med Decis Making 2007;27(4):E63-E64.

6. Fraenkel L, Miller AS, Clayton K, Crow-Hercher R, Hazel S, Johnson B, et al. When patients write the guidelines: patient panel recommendations for the treatment of rheumatoid arthritis. Arthritis Care Res (Hoboken) 2016 Jan;68(1):26-35 [FREE Full text] [doi: 10.1002/acr.22758] [Medline: 26545701]
7. Hunt LM, Arar NH. An analytical framework for contrasting patient and provider views of the process of chronic disease management. Med Anthropol Q 2001 Sep;15(3):347-367. [Medline: 11693036]
8. Krahn M, Naglie G. The next step in guideline development: incorporating patient preferences. JAMA 2008 Jul 23;300(4):436-438. [doi: 10.1001/jama.300.4.436] [Medline: 18647988]
9. Peay HL, Hollin I, Fischer R, Bridges JFP. A community-engaged approach to quantifying caregiver preferences for the benefits and risks of emerging therapies for Duchenne muscular dystrophy. Clin Ther 2014 May;36(5):624-637 [FREE Full text] [doi: 10.1016/j.clinthera.2014.04.011] [Medline: 24852596]
10. Kelson M, Akl EA, Bastian H, Cluzeau F, Curtis JR, Guyatt G, ATS/ERS Ad Hoc Committee on Integrating and Coordinating Efforts in COPD Guideline Development. Integrating values and consumer involvement in guidelines with the patient at the center: article 8 in Integrating and coordinating efforts in COPD guideline development. An official ATS/ERS workshop report. Proc Am Thorac Soc 2012 Dec;9(5):262-268. [doi: 10.1513/pats.201208-061ST] [Medline: 23256169]
11. Ollenschläger G, Marshall C, Qureshi S, Rosenbrand K, Burgers J, Mäkelä M, Board of Trustees 2002, Guidelines International Network (G-I-N). Improving the quality of health care: using international collaboration to inform guideline programmes by founding the Guidelines International Network (G-I-N). Qual Saf Health Care 2004 Dec;13(6):455-460 [FREE Full text] [doi: 10.1136/qhc.13.6.455] [Medline: 15576708]
12. Alonso-Coello P, Oxman AD, Moberg J, Brignardello-Petersen R, Akl EA, Davoli M, et al. GRADE Evidence to Decision (EtD) frameworks: a systematic and transparent approach to making well informed healthcare choices. 2: Clinical practice guidelines. BMJ 2016 Dec 30;353. [Medline: 27365494]
13. Boivin A, Currie K, Fervers B, Gracia J, James M, Marshall C, et al. Patient and public involvement in clinical guidelines: international experiences and future perspectives. Qual Saf Health Care 2010 Oct;19(5):e22. [doi: 10.1136/qshc.2009.034835] [Medline: 20427302]
14. Graham T, Alderson P, Stokes T. Managing conflicts of interest in the UK National Institute for Health and Care Excellence (NICE) clinical guidelines programme: qualitative study. PLoS One 2015;10(3) [FREE Full text] [doi: 10.1371/journal.pone.0122313] [Medline: 25811754]
15. Clinical Practice Guideline for the Recognition and Assessment of Acute Pain in Children. Oxford: Royal College of Nursing; 1999.
16. Marriot S, Lelliot P. Clinical Practice Guidelines and their Development. London: Royal College of Psychiatrists; 1994.
17. Jarrett L. A Report on a Study to Evaluate Patient/Carer Membership of the First NICE Guideline Development Groups. London: National Institute for Clinical Excellence; 2004.
18. Kelson M. The NICE Patient Involvement Unit. Evidence-based Healthcare and Public Health 2005 Aug;9(4):304-307. [doi: 10.1016/j.ehbc.2005.05.013]
19. Abdelsattar ZM, Reames BN, Regenbogen SE, Hendren S, Wong SL. Critical evaluation of the scientific content in clinical practice guidelines. Cancer 2015 Mar 01;121(5):783-789 [FREE Full text] [doi: 10.1002/cncr.29124] [Medline: 25376967]
20. National Clinical Guidelines for Stroke. London: Royal College of Physicians; 2000.
21. Browman GP, Somerfield MR, Lyman GH, Brouwers MC. When is good, good enough? Methodological pragmatism for sustainable guideline development. Implement Sci 2015 Mar 06;10:28 [FREE Full text] [doi: 10.1186/s13012-015-0222-4] [Medline: 25880370]
22. Bobo JK, Kenneson A, Kolor K, Brown MA. Adherence to American Academy of Pediatrics recommendations for cardiac care among female carriers of Duchenne and Becker muscular dystrophy. Pediatrics 2009 Mar;123(3):e471-e475. [doi: 10.1542/peds.2008-2643] [Medline: 19254982]
23. Landfeldt E, Lindgren P, Bell CF, Schmitt C, Guglieri M, Straub V, et al. Compliance to care guidelines for Duchenne muscular dystrophy. J Neuromuscul Dis 2015;2(1):63-72 [FREE Full text] [doi: 10.3233/JND-140053] [Medline: 26870664]
24. Biggar WD. Duchenne muscular dystrophy. Pediatr Rev 2006 Mar;27(3):83-88. [Medline: 16510548]
25. Bushby K, Finkel R, Birnkrant DJ, Case LE, Clemens PR, Cripe L, DMD Care Considerations Working Group. Diagnosis and management of Duchenne muscular dystrophy, part 1: diagnosis, and pharmacological and psychosocial management. Lancet Neurol 2010 Jan;9(1):77-93. [doi: 10.1016/S1474-4422(09)70271-6] [Medline: 19945913]
26. Bushby K, Finkel R, Birnkrant DJ, Case LE, Clemens PR, Cripe L, DMD Care Considerations Working Group. Diagnosis and management of Duchenne muscular dystrophy, part 2: implementation of multidisciplinary care. Lancet Neurol 2010 Feb;9(2):177-189. [doi: 10.1016/S1474-4422(09)70272-8] [Medline: 19945914]
27. Fitch K, Bernstein S, Aguilar M. The RAND/UCLA Appropriateness Method User's Manual. Santa Monica: RAND Corporation; 2001.
28. Black N, Murphy M, Lamping D, McKee M, Sanderson C, Askham J, et al. Consensus development methods: a review of best practice in creating clinical guidelines. J Health Serv Res Policy 1999 Oct;4(4):236-248. [Medline: 10623041]
29. Murphy MK, Black NA, Lamping DL, McKee CM, Sanderson CF, Askham J, et al. Consensus development methods, and their use in clinical guideline development. Health Technol Assess 1998;2(3):i-iv [FREE Full text] [Medline: 9561895]

30. Khodyakov D, Grant S, Barber CEH, Marshall DA, Esdaile JM, Lacaille D. Acceptability of an online modified Delphi panel approach for developing health services performance measures: results from 3 panels on arthritis research. J Eval Clin Pract 2017 Apr;23(2):354-360. [doi: 10.1111/jep.12623] [Medline: 27619536]
31. Khodyakov D, Hempel S, Rubenstein L, Shekelle P, Foy R, Salem-Schatz S, et al. Conducting online expert panels: a feasibility and experimental replicability study. BMC Med Res Methodol 2011 Dec 23;11:174 [FREE Full text] [doi: 10.1186/1471-2288-11-174] [Medline: 22196011]
32. Barber CEH, Marshall DA, Alvarez N, Mancini GBJ, Lacaille D, Keeling S, Quality Indicator International Panel. Development of cardiovascular quality indicators for rheumatoid arthritis: results from an international expert panel using a novel online process. J Rheumatol 2015 Sep;42(9):1548-1555 [FREE Full text] [doi: 10.3899/jrheum.141603] [Medline: 26178275]
33. Barber CEH, Marshall DA, Mosher DP, Akhavan P, Tucker L, Houghton K, Arthritis Alliance of Canada Performance Measurement Development Panel. Development of system-level performance measures for evaluation of models of care for inflammatory arthritis in Canada. J Rheumatol 2016 Mar;43(3):530-540 [FREE Full text] [doi: 10.3899/jrheum.150839] [Medline: 26773106]
34. Barber CE, Patel JN, Woodhouse L, Smith C, Weiss S, Homik J, et al. Development of key performance indicators to evaluate centralized intake for patients with osteoarthritis and rheumatoid arthritis. Arthritis Res Ther 2015 Nov 14;17:322 [FREE Full text] [doi: 10.1186/s13075-015-0843-7] [Medline: 26568556]
35. Claassen CA, Pearson JL, Khodyakov D, Satow PM, Gebbia R, Berman AL, et al. Reducing the burden of suicide in the U.S.: the aspirational research goals of the National Action Alliance for Suicide Prevention Research Prioritization Task Force. Am J Prev Med 2014 Sep;47(3):309-314. [doi: 10.1016/j.amepre.2014.01.004] [Medline: 24750971]
36. Kastner M, Bhattacharyya O, Hayden L, Makarski J, Estey E, Durocher L, et al. Guideline uptake is influenced by six implementability domains for creating and communicating guidelines: a realist review. J Clin Epidemiol 2015 May;68(5):498-509 [FREE Full text] [doi: 10.1016/j.jclinepi.2014.12.013] [Medline: 25684154]
37. Khodyakov D, Mikesell L, Schraiber R, Booth M, Bromley E. On using ethical principles of community-engaged research in translational science. Transl Res 2016 May;171:52-62. [doi: 10.1016/j.trsl.2015.12.008] [Medline: 26773561]
38. Khodyakov D, Stockdale SE, Smith N, Booth M, Altman L, Rubenstein LV. Patient engagement in the process of planning and designing outpatient care improvements at the Veterans Administration health-care system: findings from an online expert panel. Health Expect 2017 Feb;20(1):130-145 [FREE Full text] [doi: 10.1111/hex.12444] [Medline: 26914249]
39. Rubenstein L, Khodyakov D, Hempel S, Danz M, Salem-Schatz S, Foy R, et al. How can we recognize continuous quality improvement? Int J Qual Health Care 2014 Feb;26(1):6-15 [FREE Full text] [doi: 10.1093/intqhc/mzt085] [Medline: 24311732]
40. Dalal S, Khodyakov D, Srinivasan R, Straus S, Adams J. ExpertLens: a system for eliciting opinions from a large pool of non-collocated experts with diverse knowledge. Technol Forecast Soc 2011;78(8).
41. Rowe G, Gammack JG. Promise and perils of electronic public engagement. Sci Pub Pol 2004 Feb 01;31(1):39-54. [doi: 10.3152/147154304781780181]
42. Boulkedid R, Abdoul H, Loustau M, Sibony O, Alberti C. Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review. PLoS One 2011;6(6) [FREE Full text] [doi: 10.1371/journal.pone.0020476] [Medline: 21694759]
43. Nilsen ES, Myrhaug HT, Johansen M, Oliver S, Oxman AD. Methods of consumer involvement in developing healthcare policy and research, clinical practice guidelines and patient information material. Cochrane Database Syst Rev 2006 Jul 19(3):CD004563. [doi: 10.1002/14651858.CD004563.pub2] [Medline: 16856050]
44. Marshall MN. Sampling for qualitative research. Fam Pract 1996 Dec;13(6):522-525 [FREE Full text] [Medline: 9023528]
45. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J Adv Nurs 2000 Oct;32(4):1008-1015. [Medline: 11095242]
46. Khodyakov D, Pulido E, Ramos A, Dixon E. Community-partnered research conference model: the experience of Community Partners in Care study. Prog Community Health Partnersh 2014;8(1):83-97 [FREE Full text] [doi: 10.1353/cpr.2014.0008] [Medline: 24859106]
47. Guest G, MacQueen K, Namey E. Applied Thematic Analysis. Thousand Oaks: Sage; 2011.
48. Neuman L. Social Research Methods: Qualitative and Quantitative Approaches. Cranbury: Pearson Education, Inc; 2003.
49. Mays N, Pope C. Rigour and qualitative research. BMJ 1995 Jul 08;311(6997):109-112 [FREE Full text] [Medline: 7613363]
50. Basger BJ, Chen TF, Moles RJ. Validation of prescribing appropriateness criteria for older Australians using the RAND/UCLA appropriateness method. BMJ Open 2012;2(5) [FREE Full text] [doi: 10.1136/bmjopen-2012-001431] [Medline: 22983875]
51. Shekelle PG, Kahan JP, Bernstein SJ, Leape LL, Kamberg CJ, Park RE. The reproducibility of a method to identify the overuse and underuse of medical procedures. N Engl J Med 1998 Jun 25;338(26):1888-1895. [doi: 10.1056/NEJM199806253382607] [Medline: 9637810]
52. Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther 2005 Mar;85(3):257-268 [FREE Full text] [Medline: 15733050]

Abbreviations

DCN: Duchenne Connect
DMD: Duchenne muscular dystrophy
EL: ExpertLens
G-I-N: Guideline International Network
G-I-N PUBLIC: Guideline International Network Patient and Public Involvement Group
GRADE: Grading of Recommendations Assessment, Development, and Evaluation
IPR: interpercentile range
IPRAS: interpercentile range adjusted for symmetry
NICE: National Institute for Health and Care Excellence
PPMD: Parent Project Muscular Dystrophy
QDA: qualitative data analysis
RAM: RAND/UCLA Appropriateness Method
UCLA: University of California Los Angeles

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Protocol

WittyFit—Live Your Work Differently: Study Protocol for a Workplace-Delivered Health Promotion

Frédéric Dutheil[1,2,3], MD, PhD; Martine Duclos[4,5], MD, PhD; Geraldine Naughton[3], PhD; Samuel Dewavrin[6], MSc, ATPL; Thomas Cornet[6], MBA; Pascal Huguet[2], PhD; Jean-Claude Chatard[7], MD, PhD; Bruno Pereira[8], PhD

[1]Centre Hospitalier Universitaire de Clermont-Ferrand, Service Santé Travail Environnement, Clermont-Ferrand, France

[2]Université Clermont Auvergne, Centre National de la Recherche Scientifique, Laboratoire de Psychologie Sociale et Cognitive, équipe Stress physiologique et psychosocial, Clermont-Ferrand, France

[3]Australian Catholic University, Faculty of Health, School of Exercise Science, Melbourne, Victoria, Australia

[4]Centre Hospitalier Universitaire de Clermont-Ferrand, Service de Médecine du Sport, Clermont-Ferrand, France

[5]Université Clermont Auvergne, Institut National de la Recherche Agronomique, Unité de Nutrition Humaine, Centre de Recherche en Nutrition Humaine Auvergne, Clermont-Ferrand, France

[6]WittyFit, Paris, France

[7]Centre Hospitalier Universitaire de Saint-Etienne, Physiologie de l'Exercice, Laboratoire Interuniversitaire de Biologie de la Motricité Equipe d'Accueil 7424, Université de Lyon, Université Jean Monnet, Saint-Etienne, France

[8]Centre Hospitalier Universitaire de Clermont-Ferrand, Direction de la Recherche Clinique et de l'Innovation, Clermont-Ferrand, France

Corresponding Author:
Frédéric Dutheil, MD, PhD
Centre Hospitalier Universitaire de Clermont-Ferrand
Service Santé Travail Environnement
58 rue Montalembert
Clermont-Ferrand,
France
Phone: 33 06 88 22 48 48
Fax: 33 04 73 17 82 34
Email: frederic.dutheil@uca.fr

Abstract

Background: Morbidity before retirement has a huge cost, burdening both public health and workplace finances. Multiple factors increase morbidity such as stress at work, sedentary behavior or low physical activity, and poor nutrition practices. Nowadays, the digital world offers infinite opportunities to interact with workers. The WittyFit software was designed to understand holistic issues of workers by promoting individualized behavior changes at the workplace.

Objective: The shorter term feasibility objective is to demonstrate that effective use of WittyFit will increase well-being and improve health-related behaviors. The mid-term objective is to demonstrate that WittyFit improves economic data of the companies such as productivity and benefits. The ultimate objective is to increase life expectancy of workers.

Methods: This is an exploratory interventional cohort study in an ecological situation. Three groups of participants will be purposefully sampled: employees, middle managers, and executive managers. Four levels of engagement are planned for employees: commencing with baseline health profiling from validated questionnaires; individualized feedback based on evidence-based medicine; support for behavioral change; and formal evaluation of changes in knowledge, practices, and health outcomes over time. Middle managers will also receive anonymous feedback on problems encountered by employees, and executive top managers will have indicators by division, location, department, age, seniority, gender and occupational position. Managers will be able to introduce specific initiatives in the workplace. WittyFit is based on two databases: behavioral data (WittyFit) and medical data (WittyFit Research). Statistical analyses will incorporate morbidity and well-being data. When a worker leaves a workplace, the company documents one of three major explanations: retirement, relocation to another company, or premature death. Therefore, WittyFit will have the ability to include mortality as an outcome. WittyFit will evolve with the waves of connected objects further increasing its data accuracy. Ethical approval was obtained from the ethics committee of the University Hospital of Clermont-Ferrand, France.

Results: WittyFit recruitment and enrollment started in January 2016. First publications are expected to be available at the beginning of 2017.

Conclusions: The name WittyFit came from Witty and Fitness. The concept of WittyFit reflects the concept of health from the World Health Organization: being spiritually and physically healthy. WittyFit is a health-monitoring, health-promoting tool that may improve the health of workers and health of companies. WittyFit will evolve with the waves of connected objects further increasing its data accuracy with objective measures. WittyFit may constitute a powerful epidemiological database. Finally, the WittyFit concept may extend healthy living into the general population.

Trial Registration: Clinicaltrials.gov: NCT02596737; https://www.clinicaltrials.gov/ct2/show/NCT02596737 (Archived by WebCite at http://www.webcitation.org/6pM5toQ7Y)

(JMIR Res Protoc 2017;6(4):e58) doi:10.2196/resprot.6267

KEYWORDS

health; work; lifestyle; behavior; management; stress; physical activity; nutrition; sleep; musculoskeletal disorders; depression; anxiety; absenteeism; organization; morbidity; mortality; public health; mhealth; mobile app

Introduction

We spend one-third of our lives working. The age of retirement is regularly pushed back [1]. The main challenge in the near future will be to help workers maintain adequate health to do their work until retirement [1]. Morbidity before retirement carries a substantial public health and workplace burden. Therefore, there is a need to promote health globally, and targeting the workplace appears inherently appropriate. Current advances in technology offer infinite possibilities to interact with individuals universally. Software with the capacity to understand an individual within the context of the immediate environment seems to address this challenge. Workplace managers may benefit from advancing their understanding of the perceived well-being of the employees within their company.

The definition of health generated in 1948 by the World Health Organization remains fit for current purposes: “not merely the absence of disease or infirmity but a state of complete physical, mental and social well-being” [2]. Particularly, the role of well-being at work plays a major role in social well-being [3], and research remains limited by few large-scale investigations into physical and mental well-being in this setting. Therefore, we built a software tool based on three major health-related categories derived from the World Health Organization definition of health: physical, mental, and work-related well-being.

Taken separately, there is strong evidence between those factors and health-related outcomes but data are not typically gathered and synthesized in workplace settings. Within physical well-being, we investigate nutrition, physical activity, sleep, and musculoskeletal function. Current evidence strongly supports the benefits of a healthy diet. Multiple aspects of food intake and health have been investigated including the influence of eating breakfast [4] and the effect of excessive dietary sugars [5] and coffee [6] on heart health. The American College of Sports Medicine recommends a minimum of 150 minutes of moderate or 75 minutes of vigorous intensity of physical activity per week to achieve and maintain global health for adults and at least 30 minutes of moderate intensity physical activity per day [7]. Even a smaller amount [8] and even only standing [9,10] without substantially further increasing physical activity have shown benefits on life expectancy. Dose relationships have been identified between physical activity, life expectancy, and health benefits, even when sedentary individuals start to train more intensively after 50 years of age [11]. Therefore, any form of physical activity is better than no activity [7-9]. Similarly, shortened and prolonged sleep durations were associated with increased risk of mortality [12,13]. Also, for musculoskeletal function, the role of pain and pain-inducing musculoskeletal disorders were linked to relationships between perceived health and mortality [14]. By mental well-being, we investigate stress and mood. Stress is now considered a stand-alone risk factor for mortality [15]. Anxiety and depression are common and disabling conditions [16,17]. We investigate work-related well-being with validated and recognized models exploring work organization, job strain, latitude/decision-making, social support, and recognition [18-23].

There is also evidence demonstrating the relationships between physical, mental, and work-related well-being. This is particularly interesting for variables related to work. We will deliberately cite only the most common associations. High job strain and effort-reward imbalance seem to increase the risk of cardiovascular mortality [24]. Some working conditions, such as shift work, have been associated with abnormal eating behavior such as rescheduling of meals and eating different types of food (processed, sweets) [25], promoting an increased risk of developing obesity and metabolic disorders [26]. In addition, stress alone can facilitate unhealthy eating behaviors and the development of obesity [27]. Physical activity is a well-established coping mechanism for stress [28] and mental well-being [29]. Along with reduced workplace absenteeism [29,30], a strong negative association can exist between physical activity and mood states [31]. Working conditions are a strong determinant of morbidity [1,18,19,21,22,32-41]. For example, limited social support at work has been linked with cardiovascular events [42] and depression [43]. Deleterious, contagious effects of poor psychological working conditions are known to be associated with emotional exhaustion and depersonalization [44]. Changes in organization and subsequent conflict of loyalties resulting from work changes can lead to suicide [45]. Ultimately, stress at work is also a complex interplay with sleep [46], diet [47], and physical activity [48,49].

Because physical, mental, and work-related well-being are interconnected, a multifaceted and global understanding of individual perceptions may lead to better and more efficient preventive results. Despite the strong evidence of the benefits of stress management, diet counseling, and exercise training in patients, intervention studies on broad and representative

samples of employees remain scarce. Preventive programs specific to work organizations can be implemented at the worksite [50-55]. Whereas other interventional software programs focus on specific problems such as musculoskeletal disorders [56], WittyFit aims to promote health with a holistic understanding of worker health, dynamically aligned to updated scientific knowledge (evidence-based medicine). The development of the health-promoting WittyFit software will be the first interventional study with an epidemiological cohort design that is inclusive of specific details on both leisure time and working conditions, providing a global understanding of individuals. WittyFit software will support recommendations to promote more personalized health prevention initiatives focusing on physical, mental, and work-related well-being. The shorter term hypothesis is that effective use of the WittyFit software will increase well-being and improve health-related behaviors. The ultimate hypothesis of the development of the WittyFit software is that it will increase life expectancy.

Therefore, the overall aim was to build an epidemiological database generated using Wittyfit and combining major lifestyle parameters. We aim to use these data to generate initiatives for decreasing premature mortality and morbidity in conjunction with improved well-being. WittyFit will function to generate a powerful database for strengthening the evidence and advancing knowledge on the relationships between work, behavior, and health derived from a large amount of epidemiological data.

Methods

Ethics

This exploratory interventional cohort study in an ecological situation received approval from the ethics committee of the University Hospital of Clermont-Ferrand, France, and has been registered at ClinicalTrials.gov [NCT02596737]. See Multimedia Appendix 1 for the original protocol.

Participants

All workers agreeing to participate in the WittyFit study will be included from any companies willing to permit their employees to be invited to participate. The WittyFit concept follows an epidemiological design without sample size limitation. Like the Nutrinet-Santé study [57-63], the WittyFit study is never expected to end. Recruitment will commence in January 2016, and data collection will be ongoing due to the prolonged longevity of the project. Duration of participation per individual is unlimited. A staggered strategy will be to target a sample size of 200 workers from Voyages-SNCF.com within the first 6 months in order to improve and evolve the WittyFit software. WittyFit will then extend to other companies in the following year.

Outcomes

Behavioral Outcomes: Three Major Health-Related Categories (WittyFit)

Workers will answer validated questionnaires within three major health-related behavioral categories: physical, mental, and work-related well-being (Textbox 1). Each main category is divided in subcategories:

- Physical well-being investigates nutrition, physical activity, sleep, and musculoskeletal function. Nutrition will be assessed through 24-hour recalls of food intake. Physical activity combines questions about time spent in activity at work and leisure, as well as estimates of sedentary behavior time. This category also includes a questionnaire on sleep quality and quantity [46]. Musculoskeletal function is based on an adapted version of the Nordic Musculoskeletal Questionnaire [64].
- Mental well-being explores stress and mood. We will use the validated Hospital and Anxiety Depression Scale [65] and the visual analog scale of stress [66,67]. Questions on smoking and addiction will be added later.
- Work-related health questions explore job strain, latitude/decision-making, work organization and tasks, social support, and recognition. We will use the validated Job Demand-Control-Support model of Karasek [18-20] and the effort reward model of Sieigrist [21-23] with the addition of some specific questions such as visual analog scales (demand, control, etc) that we want to further validate.

Participants complete questionnaires at times convenient to them; however, participants will be prompted to complete a general visual analog scale from the main categories and major subcategories every 15 days and the more detailed questionnaires every 6 months. When a significant difference appears on the latest visual analog scale, the user is asked to complete specific questionnaires linked with the problem detected by the visual analog scale. Gaming and trophies are incentive strategies for workers to fulfill questionnaires.

Economic Outcomes and Outcomes Provided by Employers (WittyFit)

Economic data will be provided by volunteering employers from participating companies: professional roles (unskilled, skilled, mid-level workers, and senior executives), occupational sector, type of contract (full-time, part-time), absenteeism, turnover, and sales revenue and benefits. These data will be continuously updated and monitored. When a participant disappears from the database, the company will provide the relevant reason: retirement, relocation to another company, or death (premature mortality) (Textbox 1).

Medical Outcomes (WittyFit Research)

WittyFit is based on two databases: WittyFit, which deals with behavioral data, and WittyFit Research, which deals with medical data. To guarantee the highest level of security, the two databases are separate and do not interact; physicians from the University Hospital of Clermont-Ferrand will be the only researchers with access to medical data. Behavioral data (WittyFit) are those within the three major health-related categories: physical, mental, and work-related well-being. Medical data (WittyFit Research) are medical history and chronic diseases classified using the International Classification of Diseases, medications classified using the Anatomical Therapeutic Chemical classification, any clinical data known by participants such as heart rate or blood pressure, and the most common biological data such as blood glucose levels, hemoglobin A_{1c}, or blood cholesterol levels (Textbox 1).

Textbox 1. Parameters measured.

Data retrieved from self-reported questionnaires:

- WittyFit—behavioral data:
  - Physical health:
    - Nutrition
    - Physical activity
    - Sleep
    - Musculoskeletal function
  - Mental health:
    - Stress
    - Mood
    - Addiction (to be added)
  - Work-related health:
    - Job strain
    - Latitude/decision-making
    - Work orgainzation and tasks
    - Social support
    - Recognition
- Wittyfit Research—medical data:
  - Medical history and chronic diseases classified using the International Classification of Diseases
  - Medications classified using the Anatomical Therapeutic Chemical classification
  - Clinical data known by participants, such as:
    - Heart rate
    - Blood pressure
  - Common biological data known by participants, such as:
    - Blood glucose level
    - Hemoglobin A_{1c}
    - Blood cholesterol level

Data retrieved from companies—economic data:

- Continuously monitored:
  - Occupation, type of contract
  - Benefits
  - Sales revenue
  - Absenteeism
  - Turnover
  - Productivity
- When a worker (identified by human resource–generated number) disappears:
  - Retirement
  - Relocation to another company
  - Death (premature mortality)

Objectives

The shorter term objectives will be to demonstrate that WittyFit improves parameters of well-being and morbidity based on three major health-related behavioral categories. The mid-term objectives will be to demonstrate that WittyFit improves economic data of the companies such as productivity and benefits. The primary long-term objective will be to demonstrate that WittyFit will contribute to decrease premature mortality.

Confidentiality

All medical data (medical history, treatments, etc) will be only accessible from a carefully restricted WittyFit researcher access platform. All data are anonymous, and the name of the employee is never entered into the database. The database is implemented from a human resource–generated number, which is then automatically converted into another number in the WittyFit database. Data provided by employers (such as professional roles, occupational sector, type of contract, and absenteeism) are automatically associated with the human resource–generated number.

Intervention

The WittyFit program offers tiered access to employee data for those with middle- and high-level management status.

Holistic Understanding of Workers

In contrast to other interventional software focusing on a specific aim (such as relaxation or identification of musculoskeletal disorders), WittyFit aims to promote health with a holistic understanding of workers (see Figure 1) based on continuous and updated scientific knowledge (evidence-based medicine). Feedback and counseling are provided on targets (relevant goals) screened from questionnaires (see Figure 2) using an e-learning platform or a “Did you know?” information approach based on personalized analyses of responses to questionnaires.

Each e-learning module (see Figure 3) is based on a 4-step approach used in pedagogy [68-70]: (1) answer a quiz (pretest), (2) understand the issue, (3) act on the issue, and (4) answer a quiz. The quiz is designed both for learning purposes and to evaluate workers [71]. The number of questions on the quiz is based on learning techniques [72]. The planned process involves the employees accessing their own personal data on a panel of indicators displaying their status, progress, and success. Employees may also contribute new ideas in the “digital idea box” and “likes” about ideas of others (see Figure 4). Employees may participate in company-specific surveys about healthful and feasible changes in the workplace. When some changes for employees are available to consider, a red dot will appear on the access button of the relevant topic.

Figure 1. Screen capture of WittyFit: surveys foster a global understanding of workers.

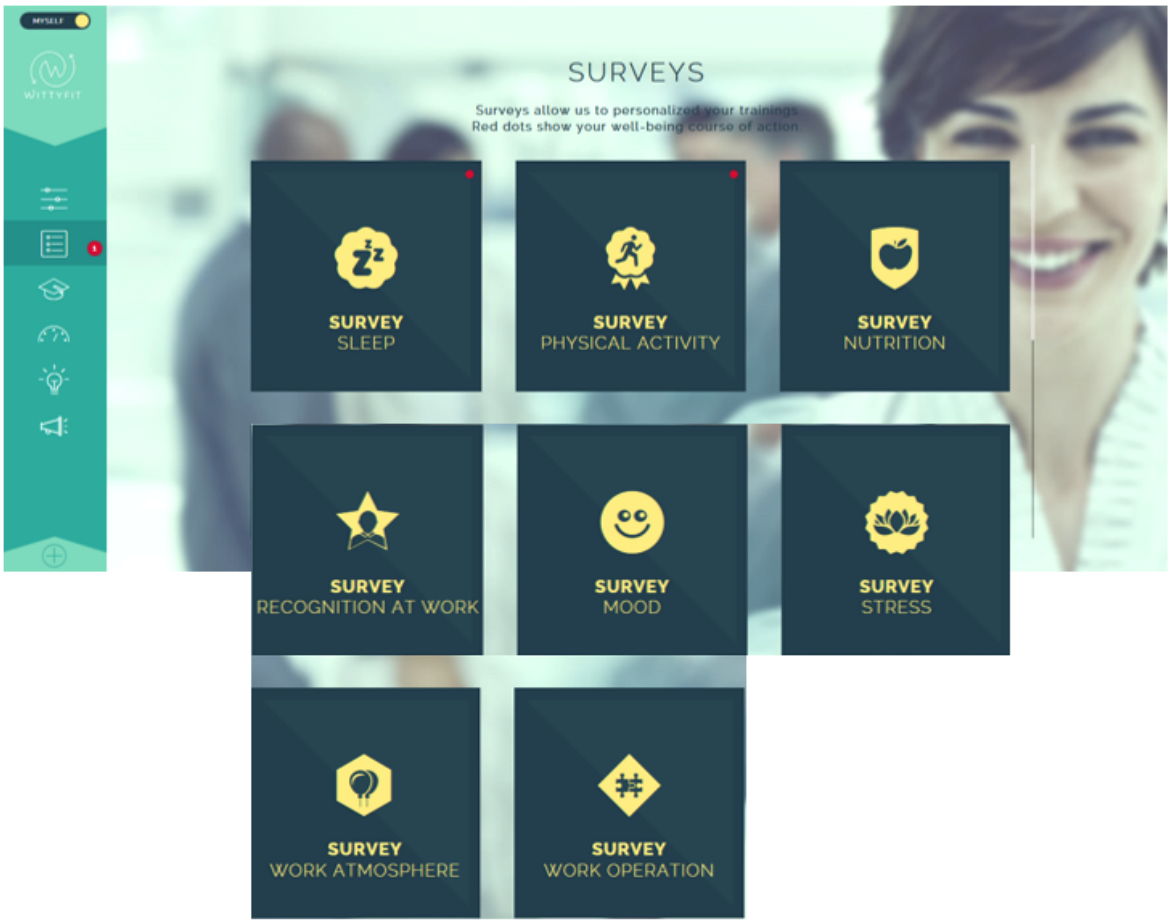


Figure 2. Screen capture of WittyFit: the homepage synthesizing the 3 major health-related categories in a personal dashboard with a menu structure on the left for access to visual analog scales, questionnaires, e-learning sessions, statistics, digital idea box, and polls.

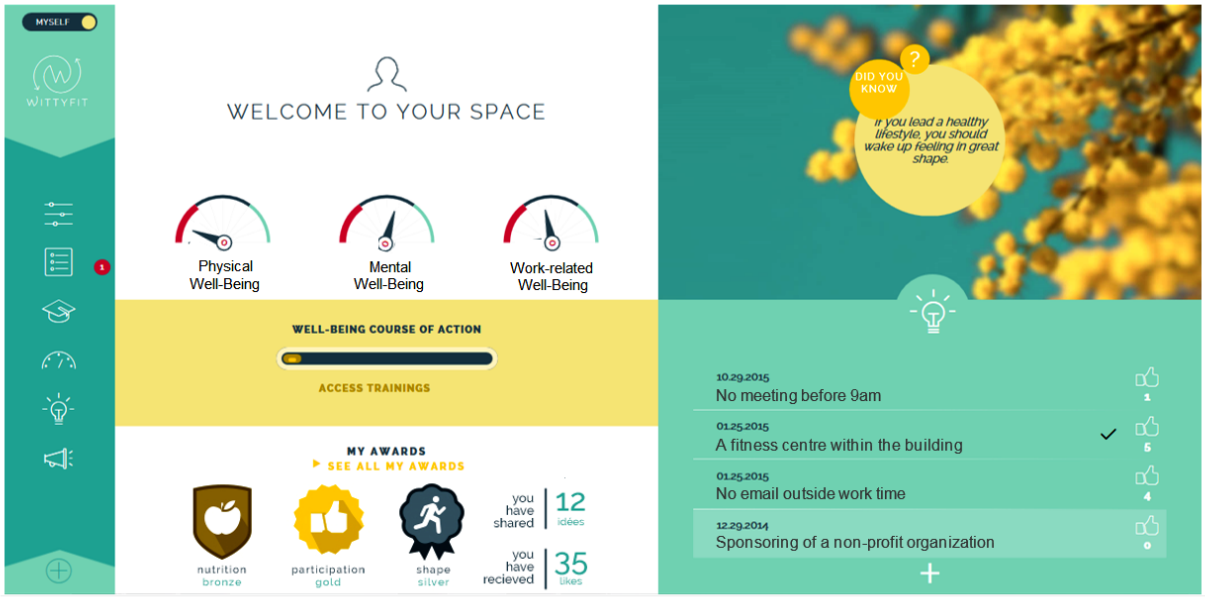


Figure 3. Screen capture of WittyFit: examples of e-learning sessions.

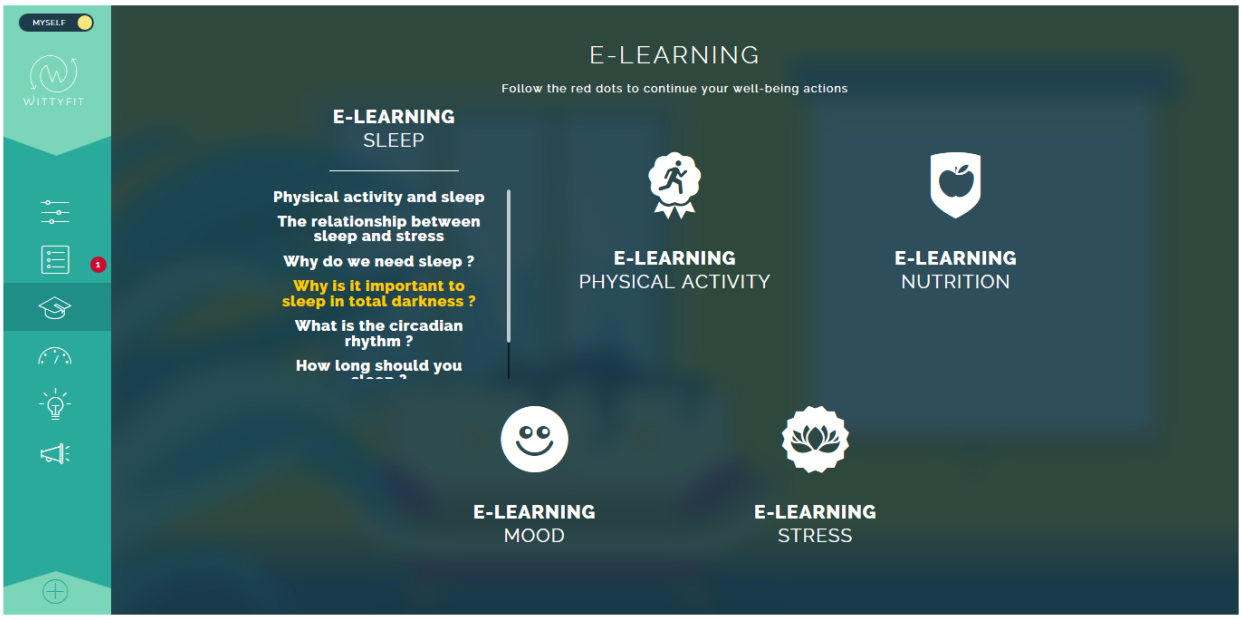
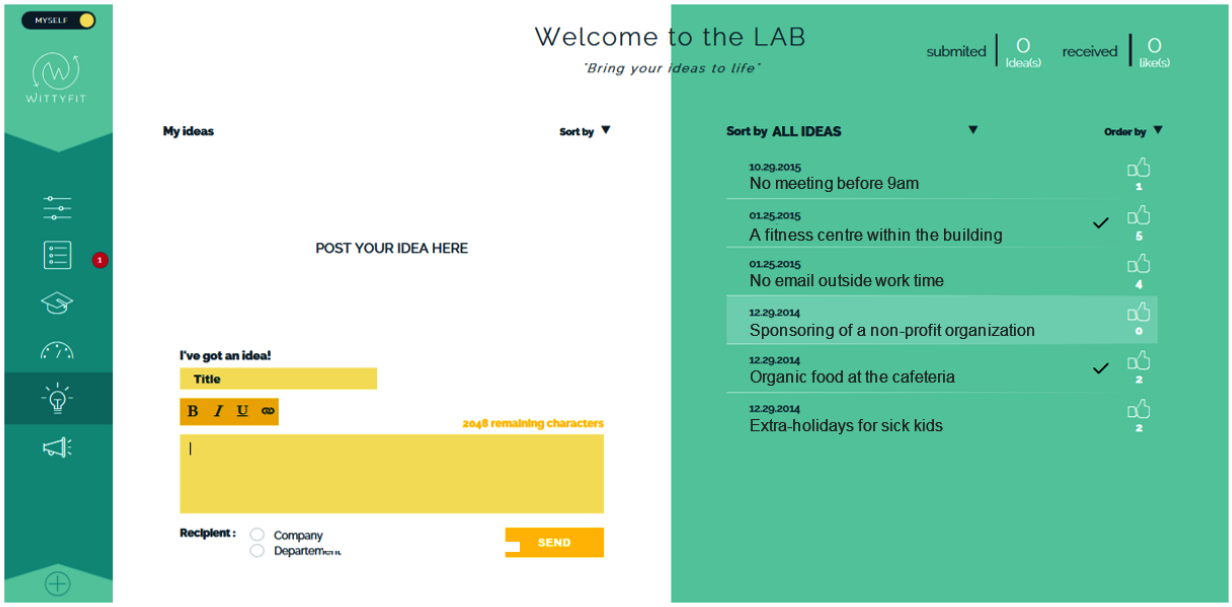


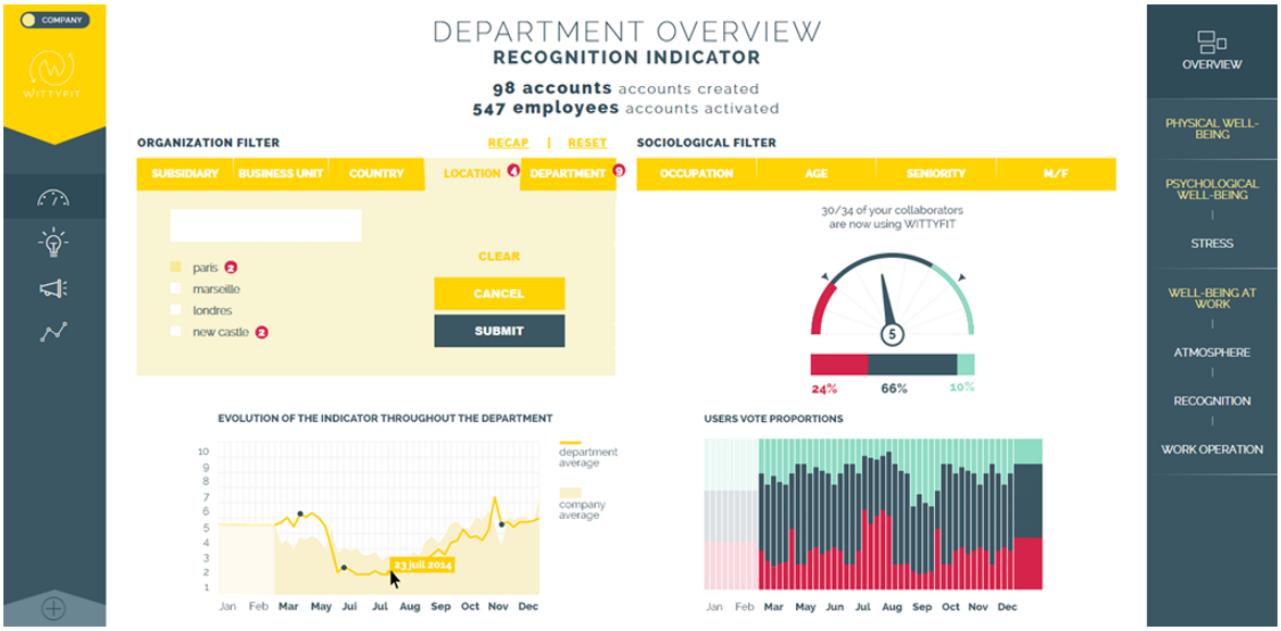
Figure 4. Screen capture of WittyFit: the Digital Idea Box.



Manager Feedback

The second feature of WittyFit is that managers will receive anonymous feedback on the general state of health and problems encountered by their employees (see Figure 5) for whole or sectional divisions of the workplace if the sample size is sufficiently high (ratios of 1/10). Middle managers will be able to target specific actions such as promoting physical activity at work or workplace initiatives assisting employees to quit smoking. They will have access to the Best Practice database. Middle managers will also have access to the Forum Manager anonymous community to share their experience. They will have a Go/No Go functionality regarding the proposals in the digital idea box. If they are not in position to decide, the middle managers can propose an idea for the top management. Executive-level managers will have similar access as the middle managers, including indicators by division, location, department, age, seniority, gender, and occupational position. In addition, executive managers will have summaries of the turnover and absenteeism within the context of the visual analog scale data profiles. They can put in motion relevant ideas from the digital idea box and use the "What's new?" editing tool to predict future changes to the work force in light of the nature of engagement of employees with the WittyFit software.

Figure 5. Screen capture of WittyFit access for top management, including anonymous mean level of stress by location, department, age, gender, occupation, etc.



Epidemiological Database

WittyFit has the capacity and innovation to strengthen evidence and build new knowledge on the relationships between lifestyle and health based on an increasing volume of epidemiological data.

Connected Objects

Eventually, WittyFit will further evolve with the waves of connected objective measures of health and lifestyle, further increasing its data relevance, with the use of devices such as pedometers, heart rate monitors, accelerometers, and thermometers. Only volunteering workers will connect these objects to WittyFit. We will soon propose devices able to analyze these objective measures. For example, we have the expertise for objective measure of stress from heart rate variability or skin conductance [73-75].

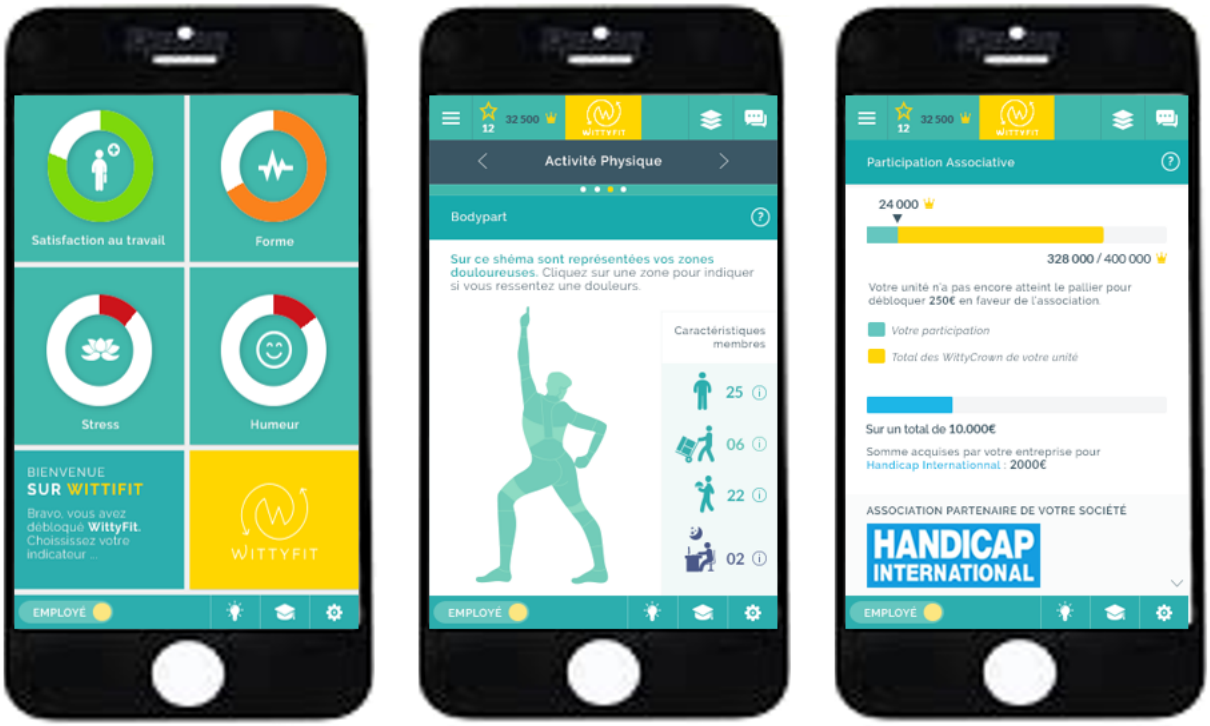
Multidisciplinary Project

WittyFit is building a spectrum of health-related data: work (shiftwork, sedentary workplace demands, specific and perhaps high-risk occupations), psychology and physiology, statistics modeling, public health, and medical health.

Friendly Use

Ease of use of Wittyfit is our goal. When an action is needed, the user can follow a link from the homepage so there is no waste of time. Users can access previous answers but can only modify specific items. Questionnaires never exceed 12 to 14 questions. Users can stop answering questionnaire and resume later where they left off. At first log-in, completing all questionnaires takes approximately 30 minutes; to reduce the burden, we ask new users to complete all questionnaires over 2 to 3 weeks. Users can refer to an interactive guide that gives them advice on what's next. WittyFit is available on any device connected to the Internet including computers, tablets, and smartphones; therefore, users can have access to WittyFit from where they want, including outside of their workplace. The gaming process is designed to increase the use of WittyFit by awarding points and badges for participation. The company is free to decide how to reward the best users with innovative strategies such as donations to nongovernmental organizations (see Figure 6).

Figure 6. Screen captures of WittyFit mobile app (French version). Left screen: homepage; middle screen: body shape to self-report musculoskeletal disorders; right screen: gaming and trophies are incentive strategies for workers to complete questionnaires.



Statistical Considerations

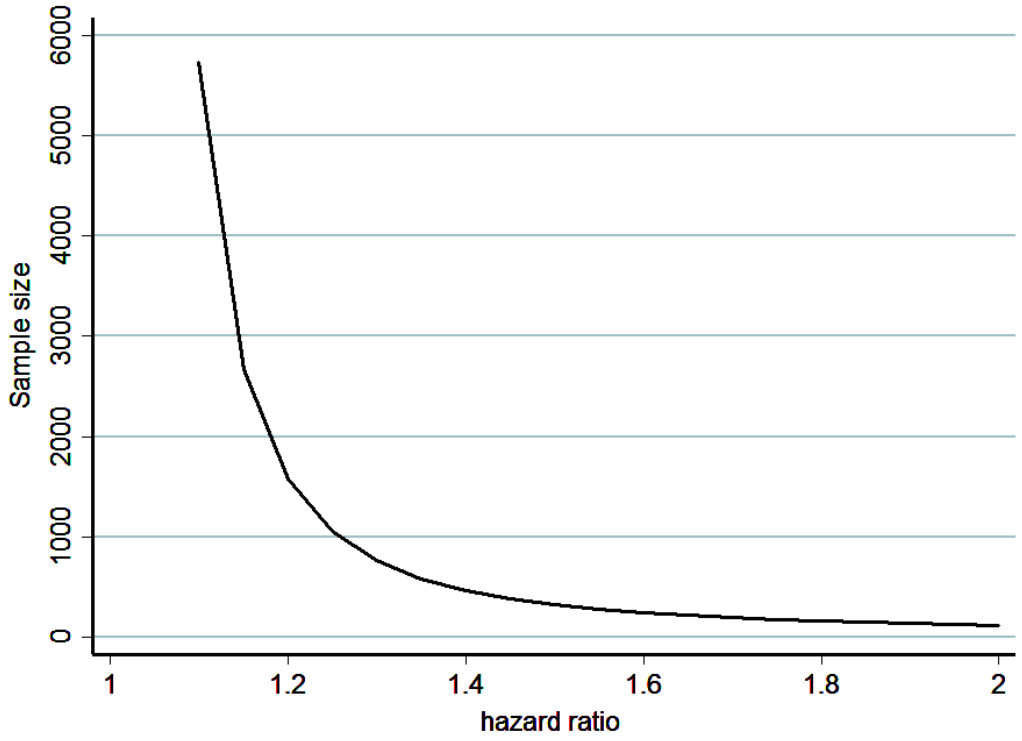
Sample Size Calculations

Using only Internet or computer interventions for behavior change outcomes improving eating disorders and nutrition [76], weight and cardiorespiratory fitness [77], or mood [78] and stress related to the workplace and performance and productivity [79], the sample size estimation was performed according to Cohen's recommendations with the following defined effect size (ES) bounds: small (ES 0.2), medium (ES 0.5), and large (ES 0.8, "grossly perceptible and therefore large") [80]. Considering an effect size of 0.33, a 2-tailed type I error fixed at a=0.001 to take into account multiple comparisons, and a moderate loss to follow-up rate, N=1000 participants will allow us to highlight (1) such ES for a statistical power greater than 95% for paired comparisons (n=225 with a correlation coefficient of .5) and (2) such ES for a statistical power greater than 80% for intergroup comparisons (n=311 by group).

For life expectancy, 100,000 workers followed over 5 years would provide a sufficient and relevant sample size to achieve the long-term objectives measured by this study. Purposive sampling will be conducted to best draw comparisons with previous research [81] studying leisure time spent sitting in relation to total mortality in a prospective cohort of US adults [9] and to further elucidate job strain among blue-collar and white-collar employees. Job strain has previously been associated with total mortality in a 28-year cohort study [82].

To address the objective of reducing premature mortality, statistical power estimation was based on a hazard ratio used for censored data (hazard ratio of 1.25 and 2) and in accordance with previously described data. This hazard ratio estimate was proposed to support a type I error of 5% (2-sided) with statistical power at 95% (see Figure 7). However, the study will be unlimited within the long-term aspects of its epidemiological design.

Figure 7. Sample size estimation for life expectancy based on simulations about hazard ratios for censored data as mortality (2-sided type I error of 5% and statistical power 95%).



Overall Statistical Analyses

Statistical analysis will be performed using Stata version 13 software (StataCorp LLC). All statistical tests will be 2-sided, and $P<.05$ will be considered significant. Quantitative variables will be described in terms of numbers, average, median, standard deviation, and range.

Analyses of Shorter Term Objectives

To study WittyFit's effect on morbidity and well-being, analyses will include comparisons with historical cohorts and literature and within the paired data from individual participants as they generate their own basis for comparison. To study longitudinal evolution of parameters associated to morbidity and well-being, models for repeated measures will be performed using a random-effects model (linear or generalized linear) along with fixed effects for descriptive data (eg, gender, age, body mass index, type of contract [full-time, part-time], professional roles [unskilled, skilled, mid-level workers, and senior executives] and occupational sector [commercial activities and service, health and social services, manufacturing/blue collar industries, finance officers]) taking into account within and between participant variability and company variability. All effect sizes will be presented with 95% confidence intervals.

When appropriate, comparisons between subgroups described above will be performed. Typical statistical tests will be applied: chi-square or Fisher exact tests for comparisons between groups from categorical parameters and analysis of variance or Kruskal-Wallis test for quantitative variables. The Shapiro-Wilk test will be used to assess normality, and the Fisher-Snedecor test to assess homoscedasticity. For censored data, the time-to-event curves will be estimated with the use of the Kaplan-Meier method. Comparisons will be performed by log-rank test. Then, Cox proportional-hazards regression models will be considered to study the prognostic factors in a multivariate situation by backward and forward stepwise modeling on the factors considered significant in univariate analysis and in accordance with parameters of clinical relevance [83,84]. The proportional-hazard hypothesis will be verified using Schoenfeld's test and plotting residuals. The interactions between possible predictive factors will also be tested. Results will be expressed as hazard ratios and 95% confidence intervals. Considering repeated correlated censored data, marginal models may be preferred.

Analyses of Longer Term Objectives

Decreased premature mortality is the long-term goal of the development of the WittyFit software. Considering this censored data, estimation will be performed as described previously using the Kaplan-Meier approach. Comparison with historical cohorts and previous research will be included in the estimates of 95% confidence intervals. WittyFit's effect will be also studied using log-ranked comparisons and a Cox proportional hazards model. Multivariate models will be used according to univariate results and clinical and epidemiological relevance.

Method Taking Into Account Missing, Unused, or Invalid Data

A sensitivity analysis of missing data will be applied to assess the level of attrition and to characterize the statistical nature (missing at random, missing completely at random, not missing at random) that will dictate the most appropriate method of imputation [85-87].

Quality Control Measures to Reduce or Avoid Bias

The data of employees will be de-identified to assessors when processing data. A large sample size will be employed to justify the validity of the statistical treatment of the data. Generalizability will be ensured via sufficient numbers in each occupational sector to represent targeted sectors.

Results

WittyFit recruitment and enrollment started in January 2016. First publications are expected to be available in 2017.

WittyFit is a multidisciplinary project. It involves leading specialists in relevant fields including epidemiologists and statisticians, occupational physicians, physiologists, psychologists, psychiatrists, and economists. Implementation and conduct of the study will be monitored by the project management committee (authors) who have extensive experience in research and conducting clinical trials in occupational health as well as statistics and engineering. Outcomes will be disseminated via open-access peer-reviewed publications, conferences, clinical networks, public lectures, and our websites. Community reports on the outcomes will also be made available to participants.

From a workplace and individual perspective, identifying stressful situations at an early stage may avoid socially problematic behavior from occurring and may permit early comprehensive and targeted behavioral intervention. We may identify unpredicted stressful events and recommend appropriate therapies. For the participants, our intervention may permit self-evaluation, giving them the chance to better anticipate and adapt to stressful situations on their own. If this protocol includes heart rate monitoring, it may also incidentally detect cardiac disorders. Such an event will be communicated to the participant with suggestions of supportive strategies. Any abnormality discovered will not be covered by insurance associated with the development of WittyFit but will be supported by typical sources of health insurance.

Discussion

Summary

The main aim of WittyFit is to provide early comprehensive and targeted behavioral interventions to improve well-being, morbidity, and ultimately life expectancy. We aim to build an epidemiological database combining major lifestyle parameters including those at work.

Morbidity before retirement has a huge cost, burdening both public health and workplace finances. Therefore, there is an urgent need for a tool such as WittyFit. WittyFit is the synthesis of several novelties. Because all parameters (physical, mental, and work-related well-being) are linked, providing a multifaceted understanding of individuals is needed. Whereas other interventional software focuses on a specific aim (relaxation, identification of musculoskeletal disorders and stress) [56], WittyFit aims to promote health with a holistic understanding of worker health, dynamically aligned to updated scientific knowledge (evidence-based medicine). Feedback is provided on targets screened from questionnaires through e-learning and personalized motivating messages.

The second novelty of WittyFit is that managers will have feedback on the general state of health and problems encountered by their employees (de-identified data), in general or by department if the sample size is sufficiently high. Managers will be able to target specific actions such as promoting physical activity at work or helping employees to quit smoking.

Third, WittyFit is a preventative tool to be used in collaboration with routine occupational medicine. It has the potential for early detection of individuals at high risk of health compromise and the functionality to direct employees to confidential health support services. This can occur by separating data into two platforms: WittyFit, which deals with behavioral data, and WittyFit Research, which deals with medical data.

Fourth, WittyFit will also evolve with more efficient questionnaires. The epidemiological design and the amount of data will permit further sensitivity analysis on questionnaires to select the most discriminant questions and disregard less useful questions. As data collection has already begun, a putative change may appear as a limitation. However, we should be able to compare and follow individuals who have responded to the same baseline questionnaires. WittyFit will have to evolve with connected objects and up-to-date science. For example, calendars of employees may be synchronized with continuous monitoring of stress provided by wrist tools measuring heart rate variability or skin conductance [73-75]. Simplification of questionnaires would therefore be useful and allow the introduction of other measurements such as job satisfaction [88] or work engagement [89]. Such parameters may be considered important aspects of physical, mental, and work-related well-being, as well as workplace productivity [90].

Potential Limitations

The considerable amount of data may delay comprehensive analysis. However, the first publications will be on easier data processing, validation of questionnaires, and relationships

between them. Health interventions designed around health behavior theory seemed most effective in changing behavior [91]. Content analyses of health software indicate that the software generally contains low levels of health behavior theory or is not adequately designed for long-term behavior change [92-95]. WittyFit is based on evidence-based practices. Even if there are widely varying professional backgrounds in WittyFit, we will further include behavioral components which may help the potential long-term development and evolution of WittyFit and which would also help to identify additional intervention targets. The findings from WittyFit should be significant for practical use in public health, especially as software and mobile apps are being increasingly used in health interventions [96]. The cost up until now to design WittyFit has been €1 million. Investments are still ongoing (and will continue) for a continuous improvement of WittyFit. This amount of money may seem huge, but dissemination of WittyFit within companies and contracts permits us to have an equilibrate business model (WittyFit was created in 2014). The challenging target will be to build a personal health system for workers with the capacity to interact with different physical activity and stress levels, sleep, or other health-related objectives using a computing system such as the one we are developing [73]. We will have the possibility to register a license and develop industrial applications.

Conclusion

In conclusion, the name WittyFit came from Witty and Fitness. The concept of WittyFit reflects the concept of health from the World Health Organization: being spiritually and physically healthy. WittyFit is a health-monitoring, health-promoting initiative that may improve the health of workers and health of companies. WittyFit will evolve with the waves of connected objects further increasing its data accuracy with objective measures. WittyFit may constitute a powerful epidemiological database. Finally, the WittyFit concept may be spread in the general population and be a generalizable useful tool for prevention.

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Authors' Contributions

FD, SD, TC, MD, and JCC were responsible of the design and conception of the study. All authors will analyze and interpret data. FD wrote the manuscript. GN and BP made critical revision of the article. All authors gave their final approval of the article. BP will be responsible for the statistical expertise.

Conflicts of Interest

TC is director of WittyFit. SD is president of WittyFit. Other authors have declared no conflicts of interest.

Multimedia Appendix 1

Original protocol.

[PDF File (Adobe PDF File), 1012KB - resprot_v6i4e58_app1.pdf]

References

1. McGonagle AK, Fisher GG, Barnes-Farrell JL, Grosch JW. Individual and work factors related to perceived work ability and labor force outcomes. J Appl Psychol 2015 Mar;100(2):376-398 [FREE Full text] [doi: 10.1037/a0037974] [Medline: 25314364]
2. Lewis DM. WHO definition of health remains fit for purpose. BMJ 2011 Aug 23;343:d5357. [Medline: 21862541]
3. Misselbrook D. W is for wellbeing and the WHO definition of health. Br J Gen Pract 2014 Nov;64(628):582 [FREE Full text] [doi: 10.3399/bjgp14X682381] [Medline: 25348979]
4. Cahill LE, Chiuve SE, Mekary RA, Jensen MK, Flint AJ, Hu FB, et al. Prospective study of breakfast eating and incident coronary heart disease in a cohort of male US health professionals. Circulation 2013 Jul 23;128(4):337-343 [FREE Full text] [doi: 10.1161/CIRCULATIONAHA.113.001474] [Medline: 23877060]
5. Te Morenga LA, Howatson AJ, Jones RM, Mann J. Dietary sugars and cardiometabolic risk: systematic review and meta-analyses of randomized controlled trials of the effects on blood pressure and lipids. Am J Clin Nutr 2014 Jul;100(1):65-79 [FREE Full text] [doi: 10.3945/ajcn.113.081521] [Medline: 24808490]
6. Ding M, Bhupathiraju SN, Satija A, van Dam RM, Hu FB. Long-term coffee consumption and risk of cardiovascular disease: a systematic review and a dose-response meta-analysis of prospective cohort studies. Circulation 2014 Feb 11;129(6):643-659 [FREE Full text] [doi: 10.1161/CIRCULATIONAHA.113.005925] [Medline: 24201300]
7. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee I, American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory,

musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011 Jul;43(7):1334-1359. [doi: 10.1249/MSS.0b013e318213fefb] [Medline: 21694556]
8. Wen CP, Wai JP, Tsai MK, Yang YC, Cheng TY, Lee M, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet 2011 Oct 1;378(9798):1244-1253. [doi: 10.1016/S0140-6736(11)60749-6] [Medline: 21846575]
9. Patel AV, Bernstein L, Deka A, Feigelson HS, Campbell PT, Gapstur SM, et al. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. Am J Epidemiol 2010 Aug 15;172(4):419-429 [FREE Full text] [doi: 10.1093/aje/kwq155] [Medline: 20650954]
10. Katzmarzyk PT. Standing and mortality in a prospective cohort of Canadian adults. Med Sci Sports Exerc 2014;46(5):940-946. [doi: 10.1249/MSS.0000000000000198] [Medline: 24152707]
11. Byberg L, Melhus H, Gedeborg R, Sundström J, Ahlbom A, Zethelius B, et al. Total mortality after changes in leisure time physical activity in 50 year old men: 35-year follow-up of population based cohort. Br J Sports Med 2009 Jul;43(7):482. [Medline: 19581403]
12. Strand LB, Tsai MK, Gunnell D, Janszky I, Wen CP, Chang S. Self-reported sleep duration and coronary heart disease mortality: A large cohort study of 400,000 Taiwanese adults. Int J Cardiol 2016 Mar 15;207:246-251. [doi: 10.1016/j.ijcard.2016.01.044] [Medline: 26808986]
13. Liu T, Xu C, Rota M, Cai H, Zhang C, Shi M, et al. Sleep duration and risk of all-cause mortality: A flexible, non-linear, meta-regression of 40 prospective cohort studies. Sleep Med Rev 2016 Mar 03. [doi: 10.1016/j.smrv.2016.02.005] [Medline: 27067616]
14. Khang Y, Kim HR. Gender differences in self-rated health and mortality association: role of pain-inducing musculoskeletal disorders. J Womens Health (Larchmt) 2010 Jan;19(1):109-116. [doi: 10.1089/jwh.2009.1413] [Medline: 20088666]
15. Stämpfli SF, Enseleit F. Stress and cardiovascular mortality: an evident but underestimated connection. Eur Heart J 2015 Jul 21;36(28):1781-1782 [FREE Full text] [Medline: 26413594]
16. Andrews G, Titov N. Depression is very disabling. Lancet 2007 Sep 8;370(9590):808-809. [doi: 10.1016/S0140-6736(07)61393-2] [Medline: 17826154]
17. Craske MG, Stein MB. Anxiety. Lancet 2016 Jun 24. [doi: 10.1016/S0140-6736(16)30381-6] [Medline: 27349358]
18. Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. Am J Public Health 1981 Jul;71(7):694-705. [Medline: 7246835]
19. Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998 Oct;3(4):322-355. [Medline: 9805280]
20. Karasek R. Job demands, job decision latitude, mental strain: implications for job redesign. Adm Sci Q 1979;24:285-308.
21. de Jonge J, Bosma H, Peter R, Siegrist J. Job strain, effort-reward imbalance and employee well-being: a large-scale cross-sectional study. Soc Sci Med 2000 May;50(9):1317-1327. [Medline: 10728851]
22. Siegrist J. Adverse health effects of high-effort/low-reward conditions. J Occup Health Psychol 1996 Jan;1(1):27-41. [Medline: 9547031]
23. Siegrist J, Klein D, Voigt KH. Linking sociological with physiological data: the model of effort-reward imbalance at work. Acta Physiol Scand Suppl 1997;640:112-116. [Medline: 9401620]
24. Kivimäki M, Leino-Arjas P, Luukkonen R, Riihimäki H, Vahtera J, Kirjonen J. Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. BMJ 2002 Oct 19;325(7369):857 [FREE Full text] [Medline: 12386034]
25. Wong H, Wong MC, Wong SY, Lee A. The association between shift duty and abnormal eating behavior among nurses working in a major hospital: a cross-sectional study. Int J Nurs Stud 2010 Aug;47(8):1021-1027. [doi: 10.1016/j.ijnurstu.2010.01.001] [Medline: 20116059]
26. Esquirol Y, Perret B, Ruidavets JB, Marquie JC, Dienne E, Niezborala M, et al. Shift work and cardiovascular risk factors: new knowledge from the past decade. Arch Cardiovasc Dis 2011 Dec;104(12):636-668 [FREE Full text] [doi: 10.1016/j.acvd.2011.09.004] [Medline: 22152516]
27. Sinha R, Jastreboff AM. Stress as a common risk factor for obesity and addiction. Biol Psychiatry 2013 May 1;73(9):827-835 [FREE Full text] [doi: 10.1016/j.biopsych.2013.01.032] [Medline: 23541000]
28. Cairney J, Kwan MY, Veldhuizen S, Faulkner GE. Who uses exercise as a coping strategy for stress? Results from a national survey of Canadians. J Phys Act Health 2014 Jul;11(5):908-916. [doi: 10.1123/jpah.2012-0107] [Medline: 23493043]
29. Bhui KS, Dinos S, Stansfeld SA, White PD. A synthesis of the evidence for managing stress at work: a review of the reviews reporting on anxiety, depression, and absenteeism. J Environ Public Health 2012 [FREE Full text] [doi: 10.1155/2012/515874] [Medline: 22496705]
30. Conn VS, Hafdahl AR, Cooper PS, Brown LM, Lusk SL. Meta-analysis of workplace physical activity interventions. Am J Prev Med 2009 Oct;37(4):330-339 [FREE Full text] [doi: 10.1016/j.amepre.2009.06.008] [Medline: 19765506]
31. Fox KR. The influence of physical activity on mental well-being. Public Health Nutr 1999 Sep;2(3A):411-418. [Medline: 10610081]

32. Cesana G, Sega R, Ferrario M, Chiodini P, Corrao G, Mancia G. Job strain and blood pressure in employed men and women: a pooled analysis of four northern italian population samples. Psychosom Med 2003;65(4):558-563. [Medline: 12883105]
33. Chandola T, Britton A, Brunner E, Hemingway H, Malik M, Kumari M, et al. Work stress and coronary heart disease: what are the mechanisms? Eur Heart J 2008 Mar;29(5):640-648 [FREE Full text] [doi: 10.1093/eurheartj/ehm584] [Medline: 18216031]
34. Chikani V, Reding D, Gunderson P, McCarty CA. Psychosocial work characteristics predict cardiovascular disease risk factors and health functioning in rural women: the Wisconsin Rural Women's Health Study. J Rural Health 2005;21(4):295-302. [Medline: 16294651]
35. Collins SM, Karasek RA, Costas K. Job strain and autonomic indices of cardiovascular disease risk. Am J Ind Med 2005 Sep;48(3):182-193. [doi: 10.1002/ajim.20204] [Medline: 16094616]
36. Evans S, Huxley P, Gately C, Webber M, Mears A, Pajak S, et al. Mental health, burnout and job satisfaction among mental health social workers in England and Wales. Br J Psychiatry 2006 Jan;188:75-80 [FREE Full text] [doi: 10.1192/bjp.188.1.75] [Medline: 16388074]
37. Goldstone AR, Callaghan CJ, Mackay J, Charman S, Nashef SA. Should surgeons take a break after an intraoperative death? Attitude survey and outcome evaluation. BMJ 2004 Feb 14;328(7436):379 [FREE Full text] [doi: 10.1136/bmj.37985.371343.EE] [Medline: 14734519]
38. Johnson JV, Hall EM. Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. Am J Public Health 1988 Oct;78(10):1336-1342. [Medline: 3421392]
39. Pisanti R, van der Doef M, Maes S, Lazzari D, Bertini M. Job characteristics, organizational conditions, and distress/well-being among Italian and Dutch nurses: a cross-national comparison. Int J Nurs Stud 2011 Jul;48(7):829-837. [doi: 10.1016/j.ijnurstu.2010.12.006] [Medline: 21257172]
40. Pomaki G, Maes S, Ter DL. Work conditions and employees' self-set goals: goal processes enhance prediction of psychological distress and well-being. Pers Soc Psychol Bull 2004 Jun;30(6):685-694. [doi: 10.1177/0146167204263970] [Medline: 15155033]
41. Schnall PL, Pieper C, Schwartz JE, Karasek RA, Schlussel Y, Devereux RB, et al. The relationship between “job strain,” workplace diastolic blood pressure, and left ventricular mass index. Results of a case-control study. JAMA 1990 Apr 11;263(14):1929-1935. [Medline: 2138234]
42. André-Petersson L, Engström G, Hedblad B, Janzon L, Rosvall M. Social support at work and the risk of myocardial infarction and stroke in women and men. Soc Sci Med 2007 Feb;64(4):830-841. [doi: 10.1016/j.socscimed.2006.10.020] [Medline: 17123677]
43. Aziah BD, Rusli BN, Winn T, Naing L, Tengku MA. Risk factors of job-related depression in laboratory technicians in Hospital Universiti Sains Malaysia (HUSM) and Kementerian Kesihatan Malaysia (KKM) hospitals in Kelantan. Southeast Asian J Trop Med Public Health 2004 Jun;35(2):468-475. [Medline: 15691158]
44. Bakker AB, Le Blanc PM, Schaufeli WB. Burnout contagion among intensive care nurses. J Adv Nurs 2005 Aug;51(3):276-287. [doi: 10.1111/j.1365-2648.2005.03494.x] [Medline: 16033595]
45. Brodsky CM. Suicide attributed to work. Suicide Life Threat Behav 1977;7(4):216-229. [Medline: 148757]
46. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989 May;28(2):193-213. [Medline: 2748771]
47. Kiecolt-Glaser JK. Stress, food, and inflammation: psychoneuroimmunology and nutrition at the cutting edge. Psychosom Med 2010 May;72(4):365-369 [FREE Full text] [doi: 10.1097/PSY.0b013e3181dbf489] [Medline: 20410248]
48. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. Sports Med 2014 Jan;44(1):81-121 [FREE Full text] [doi: 10.1007/s40279-013-0090-5] [Medline: 24030837]
49. Hansen AM, Blangsted AK, Hansen EA, Søgaard K, Sjøgaard G. Physical activity, job demand-control, perceived stress-energy, and salivary cortisol in white-collar workers. Int Arch Occup Environ Health 2010 Feb;83(2):143-153. [doi: 10.1007/s00420-009-0440-7] [Medline: 19669784]
50. Ajslev J, Brandt M, Møller JL, Skals S, Vinstrup J, Jakobsen MD, et al. Reducing physical risk factors in construction work through a participatory intervention: protocol for a mixed-methods process evaluation. JMIR Res Protoc 2016 May 26;5(2):e89 [FREE Full text] [doi: 10.2196/resprot.5648] [Medline: 27230696]
51. Brakenridge CL, Fjeldsoe BS, Young DC, Winkler EAH, Dunstan DW, Straker LM, et al. Organizational-level strategies with or without an activity tracker to reduce office workers' sitting time: rationale and study design of a pilot cluster-randomized trial. JMIR Res Protoc 2016 May 25;5(2):e73 [FREE Full text] [doi: 10.2196/resprot.5438] [Medline: 27226457]
52. Hannerz H, Larsen AD, Garde AH. Working time arrangements as potential risk factors for ischemic heart disease among workers in Denmark: a study protocol. JMIR Res Protoc 2016 Jun 22;5(2):e130 [FREE Full text] [doi: 10.2196/resprot.5563] [Medline: 27335284]
53. Pezaro S, Clyne W. Achieving consensus in the development of an online intervention designed to effectively support midwives in work-related psychological distress: protocol for a Delphi study. JMIR Res Protoc 2015;4(3):e107 [FREE Full text] [doi: 10.2196/resprot.4766] [Medline: 26341794]

54. Wakerman J, Humphreys J, Bourke L, Dunbar T, Jones M, Carey TA, et al. Assessing the impact and cost of short-term health workforce in remote indigenous communities in Australia: a mixed methods study protocol. JMIR Res Protoc 2016 Oct 03;5(4):e135 [FREE Full text] [doi: 10.2196/resprot.5831] [Medline: 27697750]
55. Wang J, Patten SB, Lam RW, Attridge M, Ho K, Schmitz N, et al. The effects of an e-mental health program and job coaching on the risk of major depression and productivity in Canadian male workers: protocol for a randomized controlled trial. JMIR Res Protoc 2016 Nov 15;5(4):e218 [FREE Full text] [doi: 10.2196/resprot.6350] [Medline: 27847352]
56. Lanhers C, Pereira B, Garde G, Maublant C, Dutheil F, Coudeyre E. Evaluation of 'I-Preventive': a digital preventive tool for musculoskeletal disorders in computer workers-a pilot cluster randomised trial. BMJ Open 2016 Sep 22;6(9):e011304 [FREE Full text] [doi: 10.1136/bmjopen-2016-011304] [Medline: 27660316]
57. Assmann KE, Bailet M, Lecoffre AC, Galan P, Hercberg S, Amieva H, et al. Comparison between a self-administered and supervised version of a Web-based cognitive test battery: results from the NutriNet-Sante cohort study. J Med Internet Res 2016 Apr 05;18(4):e68 [FREE Full text] [doi: 10.2196/jmir.4862] [Medline: 27049114]
58. Kesse-Guyot E, Andreeva V, Castetbon K, Vernay M, Touvier M, Méjean C, et al. Participant profiles according to recruitment source in a large Web-based prospective study: experience from the Nutrinet-Sante study. J Med Internet Res 2013 Sep;15(9):e205 [FREE Full text] [doi: 10.2196/jmir.2488] [Medline: 24036068]
59. Lassale C, Péneau S, Touvier M, Julia C, Galan P, Hercberg S, et al. Validity of Web-based self-reported weight and height: results of the Nutrinet-Sante study. J Med Internet Res 2013;15(8):e152 [FREE Full text] [doi: 10.2196/jmir.2575] [Medline: 23928492]
60. Méjean C, Szabo de Edelenyi F, Touvier M, Kesse-Guyot E, Julia C, Andreeva VA, et al. Motives for participating in a Web-based nutrition cohort according to sociodemographic, lifestyle, and health characteristics: the NutriNet-Sante cohort study. J Med Internet Res 2014 Aug 07;16(8):e189 [FREE Full text] [doi: 10.2196/jmir.3161] [Medline: 25135800]
61. Pouchieu C, Méjean C, Andreeva VA, Kesse-Guyot E, Fassier P, Galan P, et al. How computer literacy and socioeconomic status affect attitudes toward a Web-based cohort: results from the NutriNet-Sante study. J Med Internet Res 2015;17(2):e34 [FREE Full text] [doi: 10.2196/jmir.3813] [Medline: 25648178]
62. Camilleri GM, Méjean C, Bellisle F, Hercberg S, Péneau S. Association between mindfulness and weight status in a general population from the NutriNet-Sante Study. PLoS One 2015;10(6):e0127447 [FREE Full text] [doi: 10.1371/journal.pone.0127447] [Medline: 26038824]
63. Ducrot P, Méjean C, Julia C, Kesse-Guyot E, Touvier M, Fezeu L, et al. Effectiveness of front-of-pack nutrition labels in French adults: results from the NutriNet-Sante cohort study. PLoS One 2015;10(10):e0140898 [FREE Full text] [doi: 10.1371/journal.pone.0140898] [Medline: 26509679]
64. Descatha A, Roquelaure Y, Chastang JF, Evanoff B, Melchior M, Mariot C, et al. Validity of Nordic-style questionnaires in the surveillance of upper-limb work-related musculoskeletal disorders. Scand J Work Environ Health 2007 Feb;33(1):58-65 [FREE Full text] [Medline: 17353966]
65. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983 Jun;67(6):361-370. [Medline: 6880820]
66. Lesage FX, Berjot S. Validity of occupational stress assessment using a visual analogue scale. Occup Med (Lond) 2011 Sep;61(6):434-436 [FREE Full text] [doi: 10.1093/occmed/kqr037] [Medline: 21505089]
67. Lesage F, Berjot S, Deschamps F. Clinical stress assessment using a visual analogue scale. Occup Med (Lond) 2012 Dec;62(8):600-605 [FREE Full text] [doi: 10.1093/occmed/kqs140] [Medline: 22965867]
68. Alter MM, Borrero JC. Teaching generatively: Learning about disorders and disabilities. J Appl Behav Anal 2015;48(2):376-389. [doi: 10.1002/jaba.211] [Medline: 25917124]
69. Hemans-Henry C, Greene CM, Koppaka R. Integrating public health–oriented e-learning into graduate medical education. Am J Public Health 2012 Jun;102 Suppl 3:S353-S356. [doi: 10.2105/AJPH.2012.300669] [Medline: 22690971]
70. Núñez JC, Cerezo R, Bernardo A, Rosário P, Valle A, Fernández E, et al. Implementation of training programs in self-regulated learning strategies in Moodle format: results of a experience in higher education. Psicothema 2011 Apr;23(2):274-281. [Medline: 21504681]
71. Schiekirka S, Reinhardt D, Beißbarth T, Anders S, Pukrop T, Raupach T. Estimating learning outcomes from pre- and posttest student self-assessments: a longitudinal study. Acad Med 2013 Mar;88(3):369-375. [doi: 10.1097/ACM.0b013e318280a6f6] [Medline: 23348083]
72. Cook DA, Thompson WG, Thomas KG. Test-enhanced Web-based learning: optimizing the number of questions (a randomized crossover trial). Acad Med 2014 Jan;89(1):169-175 [FREE Full text] [doi: 10.1097/ACM.0000000000000084] [Medline: 24280856]
73. Dutheil F, Chambres P, Hufnagel C, Auxiette C, Chausse P, Ghozi R, et al. 'Do Well B.': Design Of WELL Being monitoring systems. A study protocol for the application in autism. BMJ Open 2015;5(2):e007716 [FREE Full text] [doi: 10.1136/bmjopen-2015-007716] [Medline: 25710916]
74. Woda A, Picard P, Dutheil F. Dysfunctional stress responses in chronic pain. Psychoneuroendocrinology 2016 Sep;71:127-135. [doi: 10.1016/j.psyneuen.2016.05.017] [Medline: 27262345]

75. Dutheil F, Boudet G, Perrier C, Lac G, Ouchchane L, Chamoux A, et al. JOBSTRESS study: comparison of heart rate variability in emergency physicians working a 24-hour shift or a 14-hour night shift: a randomized trial. Int J Cardiol 2012 Jul 12;158(2):322-325. [doi: 10.1016/j.ijcard.2012.04.141] [Medline: 22608270]
76. Stice E, Durant S, Rohde P, Shaw H. Effects of a prototype Internet dissonance-based eating disorder prevention program at 1- and 2-year follow-up. Health Psychol 2014 Dec;33(12):1558-1567. [doi: 10.1037/hea0000090] [Medline: 25020152]
77. Riiser K, Løndal K, Ommundsen Y, Småstuen MC, Misvær N, Helseth S. The outcomes of a 12-week Internet intervention aimed at improving fitness and health-related quality of life in overweight adolescents: the Young & Active controlled trial. PLoS One 2014;9(12):e114732 [FREE Full text] [doi: 10.1371/journal.pone.0114732] [Medline: 25478791]
78. Leykin Y, Muñoz RF, Contreras O, Latham MD. Results from a trial of an unsupported Internet intervention for depressive symptoms. Internet Interv 2014 Oct 1;1(4):175-181 [FREE Full text] [doi: 10.1016/j.invent.2014.09.002] [Medline: 25485233]
79. Chaby LE, Sheriff MJ, Hirrlinger AM, Braithwaite VA. Can we understand how developmental stress enhances performance under future threat with the Yerkes-Dodson law? Commun Integr Biol 2015;8(3):e1029689 [FREE Full text] [doi: 10.1080/19420889.2015.1029689] [Medline: 26479861]
80. Cohen J. Statistical Power Analysis for the Behavioral Sciences. New Jersey: Lawrence Erlbaum; 1988.
81. King AC, Hekler EB, Castro CM, Buman MP, Marcus BH, Friedman RH, et al. Exercise advice by humans versus computers: maintenance effects at 18 months. Health Psychol 2014 Feb;33(2):192-196. [doi: 10.1037/a0030646] [Medline: 23421896]
82. von Bonsdorff MB, Seitsamo J, von Bonsdorff ME, Ilmarinen J, Nygård C, Rantanen T. Job strain among blue-collar and white-collar employees as a determinant of total mortality: a 28-year population-based follow-up. BMJ Open 2012;2(2):e000860 [FREE Full text] [doi: 10.1136/bmjopen-2012-000860] [Medline: 22422919]
83. Harrell FE, Lee KL, Mark DB. Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. Stat Med 1996 Feb 28;15(4):361-387. [doi: 10.1002/(SICI)1097-0258(19960229)15:4<361::AID-SIM168>3.0.CO;2-4] [Medline: 8668867]
84. Malek MH, Berger DE, Coburn JW. On the inappropriateness of stepwise regression analysis for model building and testing. Eur J Appl Physiol 2007 Sep;101(2):263-264. [doi: 10.1007/s00421-007-0485-9] [Medline: 17520270]
85. Vangeneugden T, Molenberghs G, Laenen A, Alonso A, Geys H. Generalizability in nongaussian longitudinal clinical trial data based on generalized linear mixed models. J Biopharm Stat 2008;18(4):691-712. [doi: 10.1080/10543400802071386] [Medline: 18607802]
86. Zhang D. Generalized linear mixed models with varying coefficients for longitudinal data. Biometrics 2004 Mar;60(1):8-15. [doi: 10.1111/j.0006-341X.2004.00165.x] [Medline: 15032768]
87. Pourahmadi M, Daniels MJ. Dynamic conditionally linear mixed models for longitudinal data. Biometrics 2002 Mar;58(1):225-231 [FREE Full text] [Medline: 11890319]
88. Arnold AE, Coffeng JK, Boot CRL, van der Beek AJ, van Tulder MW, Nieboer D, et al. The relationship between job satisfaction and productivity-related costs: a longitudinal analysis. J Occup Environ Med 2016 Sep;58(9):874-879. [doi: 10.1097/JOM.0000000000000831] [Medline: 27454400]
89. Nerstad CGL, Richardsen AM, Martinussen M. Factorial validity of the Utrecht Work Engagement Scale (UWES) across occupational groups in Norway. Scand J Psychol 2010 Aug;51(4):326-333. [doi: 10.1111/j.1467-9450.2009.00770.x] [Medline: 20015117]
90. de Bloom J, Kinnunen U, Korpela K. Recovery processes during and after work: associations with health, work engagement, and job performance. J Occup Environ Med 2015 Jul;57(7):732-742. [doi: 10.1097/JOM.0000000000000475] [Medline: 26147541]
91. Noar SM, Zimmerman RS. Health Behavior Theory and cumulative knowledge regarding health behaviors: are we moving in the right direction? Health Educ Res 2005 Jun;20(3):275-290 [FREE Full text] [doi: 10.1093/her/cyg113] [Medline: 15632099]
92. Azar KMJ, Lesser LI, Laing BY, Stephens J, Aurora MS, Burke LE, et al. Mobile applications for weight management: theory-based content analysis. Am J Prev Med 2013 Nov;45(5):583-589. [doi: 10.1016/j.amepre.2013.07.005] [Medline: 24139771]
93. Conroy DE, Yang C, Maher JP. Behavior change techniques in top-ranked mobile apps for physical activity. Am J Prev Med 2014 Jun;46(6):649-652. [doi: 10.1016/j.amepre.2014.01.010] [Medline: 24842742]
94. Cowan LT, Van Wagenen SA, Brown BA, Hedin RJ, Seino-Stephan Y, Hall PC, et al. Apps of steel: are exercise apps providing consumers with realistic expectations? A content analysis of exercise apps for presence of behavior change theory. Health Educ Behav 2013 Apr;40(2):133-139. [doi: 10.1177/1090198112452126] [Medline: 22991048]
95. Direito A, Dale LP, Shields E, Dobson R, Whittaker R, Maddison R. Do physical activity and dietary smartphone applications incorporate evidence-based behaviour change techniques? BMC Public Health 2014;14:646 [FREE Full text] [doi: 10.1186/1471-2458-14-646] [Medline: 24965805]
96. Payne HE, Lister C, West JH, Bernhardt JM. Behavioral functionality of mobile apps in health interventions: a systematic review of the literature. JMIR Mhealth Uhealth 2015;3(1):e20 [FREE Full text] [doi: 10.2196/mhealth.3335] [Medline: 25803705]

Abbreviations

ES: effect size

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Protocol

Establishing Linkages Between Distributed Survey Responses and Consumer Wearable Device Datasets: A Pilot Protocol

Julia E Brinton[1], MA; Mike D Keating[1], MA; Alexa M Ortiz[1], MSN; Kelly R Evenson[1,2], PhD; Robert D Furberg[1], PhD

[1]RTI International, Durham, NC, United States

[2]Gillings School of Global Public Health, Department of Epidemiology, University of North Carolina, Chapel Hill, NC, United States

Corresponding Author:
Julia E Brinton, MA
RTI International
3040 E Cornwallis Dr
Durham, NC, 27709
United States
Phone: 1 919 485 5613
Fax: 1 919 990 8454
Email: jbrinton@rti.org

Abstract

Background: As technology increasingly becomes an integral part of everyday life, many individuals are choosing to use wearable technology such as activity trackers to monitor their daily physical activity and other health-related goals. Researchers would benefit from learning more about the health of these individuals remotely, without meeting face-to-face with participants and avoiding the high cost of providing consumer wearables to participants for the study duration.

Objective: The present study seeks to develop the methods to collect data remotely and establish a linkage between self-reported survey responses and consumer wearable device biometric data, ultimately producing a de-identified and linked dataset. Establishing an effective protocol will allow for future studies of large-scale deployment and participant management.

Methods: A total of 30 participants who use a Fitbit will be recruited on Mechanical Turk Prime and asked to complete a short online self-administered questionnaire. They will also be asked to connect their personal Fitbit activity tracker to an online third-party software system, called Fitabase, which will allow access to 1 month's retrospective data and 1 month's prospective data, both from the date of consent.

Results: The protocol will be used to create and refine methods to establish linkages between remotely sourced and de-identified survey responses on health status and consumer wearable device data.

Conclusions: The refinement of the protocol will inform collection and linkage of similar datasets at scale, enabling the integration of consumer wearable device data collection in cross-sectional and prospective cohort studies.

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KEYWORDS

Fitbit; Mturk; mHealth; clinical research protocol; consumer wearable; physical activity tracker

Introduction

The increasing variety, functionality, and storage capacity of consumer wearable devices has created an opportunity for using the data collected on these devices for research purposes. Consumer wearables are most commonly worn on the wrist but may also be worn on clothing, at the waist, or as part of eyewear or earwear. In this paper, we focus on activity trackers, a type of consumer wearable which can collect a variety of data including steps, distance, physical activity, calories burned, quality and duration of sleep, heart rate, and location [1]. Researchers would benefit from being able to remotely gather and link these data without the need for face-to-face interaction, encouraging the use of the respondent's own devices in the data collection process.

A remote data collection protocol would reduce the cost of providing devices to participants, reduce the time spent meeting and training respondents on their use, and increase the speed at which data could be collected [2]. Furthermore, with the ability to efficiently collect health data remotely, hospitals, worksites,

and other health care providers could monitor participants in real time, reducing the need for frequent check-ups and the financial strain that is associated with those appointments [3]. The utility and success of remote-access interventions was demonstrated to be effective in collecting biometric (eg, continuous heart rate, sleep, and other health indicators) [4] data, yet research using consumer wearable devices is limited and presents challenges.

While research investigating the viability and functionality of consumer wearables has increased in recent years, thanks in part to calls for research from the National Institutes of Health and United Nations International Children's Fund, challenges still exist in the utility of these devices as the most efficient and useful way to learn about the health of an individual. Frequently, remote data collection may be hindered by burdensome notification systems, forcing individuals to use study-provided devices they are not comfortable with and requiring frequent face-to-face contact with participants in order to download data from their devices. For example, many present studies employ experience sampling methodology, which requires that researchers notify participants throughout the day requesting that they provide their remote data, a burdensome process for both respondents and researchers [5,6,7]. They often frequently require that participants travel to the researcher's location in order to allow for the data to be downloaded. Furthermore, in regard to biometric tracking data, researchers are often required to call upon the services of a third-party software company to extract the data because there currently lacks a system that allows remote access to consumer devices for data extraction purposes [8]. Finally, many health-related research studies intend to collect data from a variety of mediums including physiologic data such as heart rate and self-reported questionnaire data such as how participants view their health. The result is a cumbersome data collection process that does not allow for a smooth data acquisition and linkage process of data from varying modes of collection.

This study seeks to explore a protocol whereby physical activity and health-related data are collected remotely through the use of personally owned activity trackers without the need for a face-to-face meeting with the respondents and without the use of study-provided devices. The primary aim of the study will be determining the feasibility of the proposed data collection protocol using an activity tracker and specifically if we are able to pair consumer wearable physiological data (ie, information from a Fitbit activity tracker) together with self-reported questionnaire data in order to have a better understanding of the health of respondents.

Methods

Ethics

Prior to initiation, this study will be reviewed and approved by the RTI International Institutional Review Board.

Participant Eligibility Criteria

This study will make use of a panel of Mturkers via Amazon's Mechanical Turk (Mturk) platform. Mturkers are a workforce of individuals willing to participate in online research studies in exchange for money deposited into their Amazon.com personal account. With the help of Mturk Prime, this study will use Mturkers as a basis for the sample. Mturk Prime operates as a team of online support staff who assist researchers in managing, communicating with, and collecting data from Mturkers (www.turkprime.com). Research using Mturkers has increased dramatically in the past few years due to the low cost and vast acquisition of data [9]. Additionally, studies show that Mturkers are more demographically diverse than standard convenience samples and samples from other online forms of data collection such as Twitter [10] and may be generalizable to the greater population [11,12]. In order for an Mturker to become a part of this study's panel, the person will be required to either keep track of their own weight, diet, or exercise routine or keep track of their own blood pressure, blood sugar, sleep patterns, headaches, or some other health-related indicator. An eligible Mturker must also be at least 18 years of age, regularly wear a Fitbit, and be willing to give the research team access to their Fitbit data for the previous month and the upcoming month from the date of sign-up.

Study Design and Procedure

The sample will consist of 30 Mturk participants. Participants will read a short task description and compensation information on Mturk's research studies advertisement page. Interested participants will be asked to click a link directing them to a series of eligibility questions. If they qualify for the study based on their answers, participants will complete an electronic informed consent and become part of the Mturk Prime panel. All panelists will receive a unique numeric participant ID. Once the panel is confirmed, all 30 panelists will complete a health questionnaire that assesses demographics, general health, physical activity, health tracking processes, and consumer technology (see Multimedia Appendix 1 for full questionnaire specifications including skip logic and response codes). Participants will be asked to enter their unique participant ID into a text box at the start of the questionnaire. At the end of the questionnaire, participants will be queried for their willingness to allow researchers to download their Fitbit data. All varieties and models of Fitbit will be allowed in this study (a range of devices is summarized in the research of Evenson et al [13]).

Upon consent to Fitbit data access, participants will be routed to a third-party data service provider called Fitabase LLC (San Diego, California). Using the Fitbit application programming interface, third-party services such as Fitabase can access and aggregate self-tracker data. Fitabase provides researchers with a connection to the Fitbit infrastructure to support data collection. The research team will generate unique Fitabase links for each participant. When respondents reach the end of the self-administered survey, they will click on the link to Fitabase that corresponds to their participant ID (Figure 1). Upon completion of the Fitabase sign-up, participants will be given $10 via Mturk Prime's customer service team. Participants who complete the questionnaire but do not sign up with Fitabase will not receive the $10 incentive. Participants can refuse to participate or cancel registration at any time. We will contract with Fitabase to provide the research team with 30 days of retrospective data and 30 days of prospective data, both from

the date of sign-up. After the 30 days of prospective data are complete, Fitabase will terminate the connection to the individuals' Fitbit device.

Study Proposed Variables

Fitabase will be used to extract daily and intraday data from the linked Fitbit accounts. These variables include daily-level data on total steps, distance, calories burned, total sleep time, and daily active versus sedentary time. We will also obtain hourly-level data on calories burned, active versus sedentary time, heart rate, sleep, and step counts. The most granular output, intraday data, will include minute-level step counts. These data will be downloaded as both raw and aggregated files by day, per person.

Study Outcomes and Data Analysis

Overview

This study's main goal is to test the feasibility of extracting personal Fitbit data from remote survey respondents with whom the research team will never have direct face-to-face contact and then linking the biometric data to self-reported questionnaire health data. Ease of contact, maintenance, troubleshooting, and collecting participant Fitbit data throughout the study will be a vital determinant of success. More specifically, the success of the protocol will be measured by the ability to collect data from participants without face-to-face contact and high costs but with fast data acquisition and the ability to easily contact participants if there is any trouble with data collection or incentive payment.

Future analyses are planned for the physiological and self-administered data to be collected throughout the study. The following data management and data analysis plans briefly outline the proposed future acquisition, management, and analysis of these data.

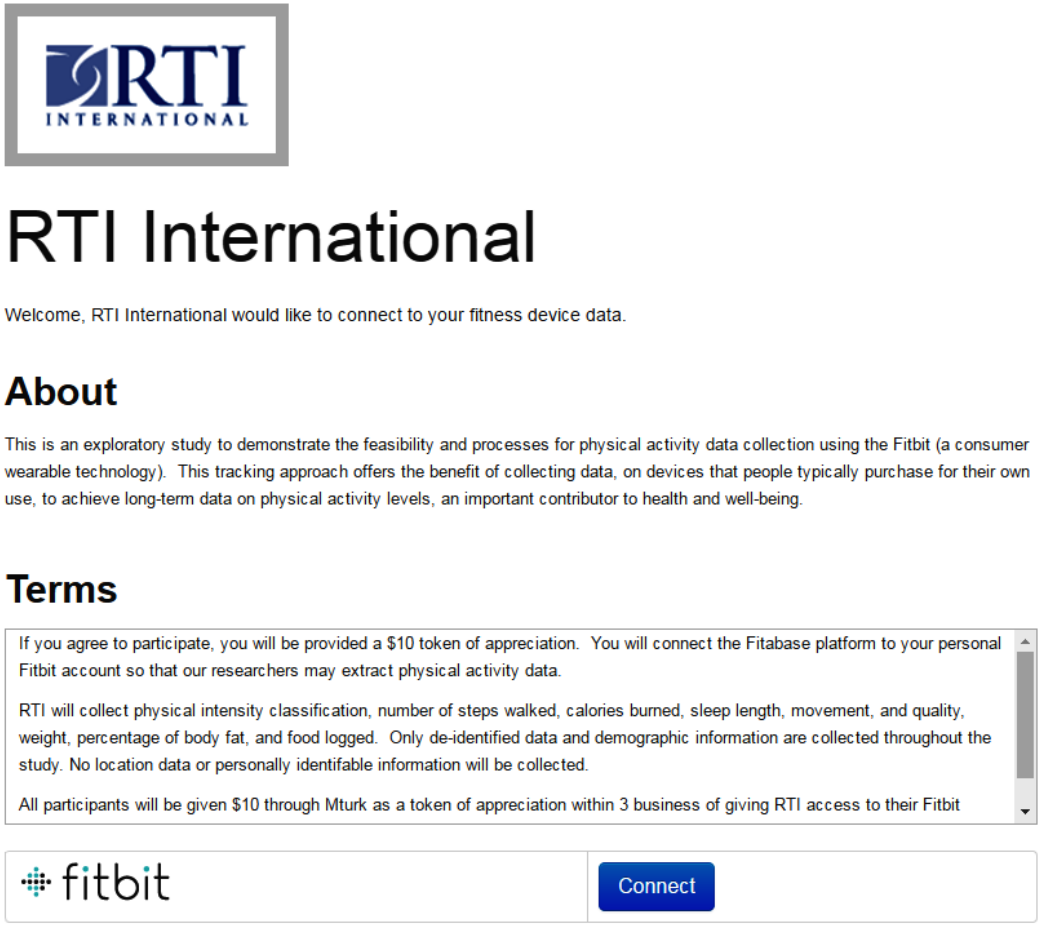
Data Management

Study IDs will be assigned to each participant. The consumer device account identifiers will then be mapped to the assigned IDs. Once the survey is complete, the responses will be exported to comma-separated value (CSV) files. Separately, the consumer wearable datasets will be processed and sent to the researchers from Fitabase. Both the survey responses and the consumer wearable dataset will be merged by ID as a de-identified, compressed CSV file and formatted for analysis.

Data Analysis

Descriptive statistics will be generated for each variable. We do not expect missing data to be an issue but will explore as appropriate. The variability in Fitbit device type will be described, as well as the type, quality, and fidelity of the data collected. We will explore the Fitbit results with self-reported characteristics such as how steps per day vary by gender and age.

Figure 1. Example screen showing the Fitabase linkage.



Results

Data collection was conducted between April 11, 2016, and May 12, 2016. Data analysis will take place in 2017.

Discussion

Summary

This study provides a unique and innovative protocol for remote data collection using a common physical activity tracker. The study will be cost effective and easily manageable in that researchers do not need to meet with participants face-to-face at any point in the study and participants are able to use their own personal device to participate in the study.

With the acquisition of these data, we will be able to learn detailed information about the health of these individuals without meeting the participant face-to-face for an interview or in-person physiological assessments. Furthermore, we will learn more about the ease at which participants navigated the questionnaire-to-Fitabase linkage system by determining what proportion of participants were able to complete the online questionnaire but were unable to connect their personal Fitbit to the Fitabase platform. Finally, these data will indicate the frequency at which users sync their Fitbit, allowing us to learn more about the normal use and wearing habits of Fitbit users.

Limitations

This feasibility study has several limitations. First, this study is targeted to a specific population, and Mturkers may not be generalizable to other populations. However, Mturkers are familiar with the online environment and therefore may be more adept at performing tasks with technology, thus making feasibility of the protocol administration more likely to be successful.

Second, this study will require respondents to have access to a Fitbit device in order to participate. Individuals who can afford and use Fitbit devices and other consumer wearables are more likely to be younger (between the ages of 18 and 34 years) and affluent [14], thus impacting generalizability. Third, the initial process of gathering a panel of participants will require respondents to complete a screener and then at a later date, complete a questionnaire in order to allow researchers to choose a varied participant pool who all use Fitbit devices. A more streamlined process would be preferred in future studies whereby participants would be able to fill out the screener and immediately begin the questionnaire if they are eligible, without the need to create a panel of participants. Unfortunately, this study will not be able to employ this methodology due to panel restrictions.

Conclusion

This study will demonstrate that activity tracker data (ie, Fitbit data) can be remotely gathered from participants without face-to-face contact and with the use of respondent's personal consumer wearable devices. Future research could investigate the feasibility of remote data collection without the need of a 2-step data management process as well as assess the clinical validity of consumer wearable devices, like Fitbit, to ensure that the data are accurate. If effective, this methodology could be used as a guide for researchers to implement when setting up a remote data collection system and could be applied to other consumer wearable devices as well.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Survey specifications for questionnaire to assess demographics, general health, physical activity, health tracking processes, and consumer technology adoption.

[PDF File (Adobe PDF File), 115KB - resprot_v6i4e66_app1.pdf]

References

1. Fitbit: Our Technology. URL: https://www.fitbit.com/technology [accessed 2017-04-08] [WebCite Cache ID 6pa1bf4p4]
2. Ortiz AM, Tueller SJ, Cook SL, Furberg RD. ActiviTeen: a protocol for deployment of a consumer wearable device in an academic setting. JMIR Res Protoc 2016 Jul;5(3):e153 [FREE Full text] [doi: 10.2196/resprot.5934] [Medline: 27457824]
3. Ahern DK, Kreslake JM, Phalen JM. What is eHealth (6): perspectives on the evolution of eHealth research. J Med Internet Res 2006 Mar;8(1):e4 [FREE Full text] [doi: 10.2196/jmir.8.1.e4] [Medline: 16585029]
4. Dobkin BH. Wearable motion sensors to continuously measure real-world physical activities. Curr Opin Neurol 2013 Dec;26(6):602-608 [FREE Full text] [doi: 10.1097/WCO.0000000000000026] [Medline: 24136126]
5. Ilies R, Dimotakis N, De Pater IE. Psychological and physiological reactions to high workloads: implications for well-being. Personnel Psychol 2010;63(2):407. [doi: 10.1111/j.1744-6570.2010.01175.x]

6. Ebner-Priemer UW, Trull TJ. Ambulatory assessment. Eur Psychol 2009 Jan;14(2):109-119. [doi: 10.1027/1016-9040.14.2.109]
7. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Ann Rev Clin Psychol 2008 Apr;4(1):1-32. [doi: 10.1146/annurev.clinpsy.3.022806.091415]
8. Cadmus-Bertram L, Marcus BH, Patterson RE, Parker BA, Morey BL. Use of the Fitbit to measure adherence to a physical activity intervention among overweight or obese, postmenopausal women: self-monitoring trajectory during 16 weeks. JMIR Mhealth Uhealth 2015 Nov;3(4):e96 [FREE Full text] [doi: 10.2196/mhealth.4229] [Medline: 26586418]
9. Christenson D, Glick D. Crowdsourcing panel studies and real-time experiments in Mturk. Political Methodologist 2013;20(2).
10. Casler K, Bickel L, Hackett E. Separate but equal? A comparison of participants and data gathered via Amazon's MTurk, social media, and face-to-face behavioral testing. Comp Hum Behav 2013 Nov;29(6):2156-2160. [doi: 10.1016/j.chb.2013.05.009]
11. Buhrmester M, Kwang T, Gosling SD. Amazon's Mechanical Turk: a new source of inexpensive, yet high-quality, data? Perspect Psychol Sci 2011 Feb 03;6(1):3-5. [doi: 10.1177/1745691610393980]
12. Goodman J, Cryder CE, Cheema A. Data collection in a flat world: the strengths and weaknesses of Mechanical Turk samples. Behav Decis Making 2013.
13. Evenson KR, Goto MM, Furberg RD. Systematic review of the validity and reliability of consumer-wearable activity trackers. Int J Behav Nutr Phys Act 2015;12(1):159 [FREE Full text] [doi: 10.1186/s12966-015-0314-1] [Medline: 26684758]
14. Callaway J, Rozar T. Quantified wellness: wearable technology usage and market summary. RGA Reinsurance Company 2015.

Abbreviations

CSV: comma-separated values
Mturk: Mechanical Turk

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Protocol

Exploring Workarounds Related to Electronic Health Record System Usage: A Study Protocol

Vincent Blijleven[1,2], MSc; Kitty Koelemeijer[1], PhD; Monique Jaspers[2], PhD

[1]Center for Marketing & Supply Chain Management, Nyenrode Business University, Breukelen, Netherlands

[2]Academisch Medisch Centrum, Department of Medical Informatics, University of Amsterdam, Amsterdam, Netherlands

Corresponding Author:
Vincent Blijleven, MSc
Center for Marketing & Supply Chain Management
Nyenrode Business University
Straatweg 25
Breukelen, 3621 BG
Netherlands
Phone: 31 630023248
Fax: 31 346291250
Email: v.b.blijleven@amc.uva.nl

Abstract

Background: Health care providers resort to informal temporary practices known as workarounds for handling exceptions to normal workflow that are unintentionally imposed by electronic health record (EHR) systems. Although workarounds may seem favorable at first sight, they are generally suboptimal and may jeopardize patient safety, effectiveness, and efficiency of care. Identifying workarounds and understanding their motivations, scope, and impact is pivotal to support the design of user-friendly EHRs and achieve closer alignment between EHRs and work contexts.

Objective: We propose a study protocol to identify EHR workarounds and subsequently determine their scope and impact on health care providers' workflows, patient safety, effectiveness, and efficiency of care. First, knowing whether a workaround solely affects the health care provider who devised it, or whether its effects extends beyond the EHR user to the work context of other health care providers, is key to accurately assessing its degree of influence on the overall patient care workflow. Second, knowing whether the consequence of an EHR workaround is favorable or unfavorable provides insights into how to address EHR-related safety, effectiveness, and efficiency concerns. Knowledge of both perspectives can provide input on optimizing EHR designs.

Methods: In the study, a combination of direct observations, semistructured interviews, and qualitative coding techniques will be used to identify, analyze, and classify EHR workarounds. The research project will be conducted within three distinct pediatric care processes and settings at a large university hospital.

Results: Data was collected using the described approach from January 2016 to March 2017. Data analysis is underway and is expected to be completed in May 2017. We aim to report the results of this study in a follow-up publication.

Conclusions: This study protocol provides a grounded framework to explore EHR workarounds from a holistic and integral perspective. Insights from this study can inform the design and redesign of EHRs to further align with work contexts of healthcare professionals, and subsequently lead to better organization and safer provision of care.

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KEYWORDS

electronic health records; qualitative research; workarounds; unintended consequences; physicians; nurses; administrative personnel

Introduction

In recent years, an increasing number of hospitals around the world have implemented electronic health record (EHR) systems [1-3]. According to 2015 American Hospital Association survey data, 83.8% of all US non-federal acute care hospitals have adopted at least a basic EHR, representing an almost nine-fold increase since 2008 (9.4%) [4]. EHRs can improve the ways that medical information is stored, communicated, and processed by those involved in delivering health care [5]. Preventable

adverse events in health care frequently relate to the unavailability of important patient information, but in this context health information technology such as EHRs hold promise for improving the quality of information transfer [6].

Multiple studies have reported on desirable outcomes of EHRs. Examples include improvements related to patient safety [7-9], quality of care [9-11], efficiency [9,12-15], and reduced costs [16,17]. However, achieving these merits expected from EHRs is far from evident. Many other studies likewise address unfavorable and often unanticipated outcomes of adopting EHRs, such as health care providers suffering from *alert fatigue* [18,19], paper persistence [20-22], workflow mismatches [23], difficulties in finding the right information in the systems [24], never-ending system demands [25], or an EHR interface that is unsuitable for a highly interruptive health care context [26].

These undesirable and unanticipated consequences of EHR adoption can have negative and unintended effects on the overall health care organization and its work processes (and the outcomes thereof), and have frequently been subject to further examination. When the practices of health care providers are unintentionally but negatively influenced by mismatches between EHR designs and actual workflows, providers devise so-called *workarounds*. Workarounds can be defined as, "informal temporary practices for handling exceptions to normal workflow" [27] or, "staff actions that do not follow explicit or implicit rules, assumptions, workflow regulations, or intentions of systems designers" [28]. Workarounds are solutions to workflow mismatches that help to coordinate work, especially under conditions of high time pressure. Existing literature shows that system users may devise workarounds as a consequence of: a perceived lack of efficiency causing the user to execute the task at hand in a different manner, task complexity dictating workflow or system functionality issues, no correct or desired option being available in the system-dictated workflow, no options for customizing the system output, or a lack of trust in electronic versus paper-based communication [20-22,26,27,29].

Although workarounds may solve the exceptions that EHRs impose upon the ordinary workflows of their users, they are generally suboptimal, as the EHR fails to live up to the goals of its implementation (ie, improving the practices of health care providers) and may negatively influence the safety, effectiveness, and efficiency of care. Understanding why and how workarounds occur is pivotal to develop user-friendly EHRs, and to achieve greater alignment between work context and the EHR [22]. Research into workarounds has a prominent place in health care, and workarounds have been identified, analyzed, and described in various contexts [20,30-34].

To date, research into the scope and impact of EHR usage-related workarounds on overall patient care processes has been limited. First, concerning the scope of EHR workarounds, it is crucial to know whether a workaround affects a single EHR user who devised it, or whether its effects extend beyond the EHR user to the work context of other health care providers, to accurately assess its impact on the overall patient care workflow. Second, knowing whether the consequence of an EHR workaround is favorable or unfavorable provides insights into how to address EHR-related safety, effectiveness, and efficiency concerns. Knowledge of both perspectives can provide input on optimizing EHR design.

This study protocol proposes a way of identifying, analyzing, and classifying EHR workarounds to determine their scope and impact on the patient care process. Within a large university hospital, we intend to conduct direct observations of (and semistructured interviews with) health care providers while they use EHRs in three different processes, each taking place in a distinct physical environment: the preparation of outpatient consultations in private offices of health care professionals, actual outpatient consultations in examination rooms, and actual inpatient consultations with admitted patients in wards. The research design, clinical setting, and methods to be used in the research project are described in the following section.

Methods

Study Design

To address the aim of determining the scope and impact of EHR-related workarounds, we adapted one of the most widely used health care human factors systems frameworks, the Systems Engineering Initiative for Patient Safety (SEIPS) framework [35]. The SEIPS framework corresponds with Donabedian's structure-process-outcome framework [36] for examining health care services and evaluating quality of health care. SEIPS provides an integral conceptual framework for applying systems engineering concepts to identify and analyze workarounds in specific health care contexts. Workarounds in health care settings have been found to differ as a function of people's roles, and can have a cascading effect (meaning that workarounds can trigger a series of further workarounds) [27]. Using the integrated and holistic perspective of the SEIPS framework, relationships between health care work systems, processes, and resulting outcomes can be studied together, rather than each in isolation. The SEIPS framework has already proven valuable in studying workarounds in various health care contexts [28,37]. As illustrated in Figure 1, the framework consists of three main components: the *work system*, including persons, tasks, tools and technologies, organization, and the internal environment; *processes* within the work system; and *outcomes* that result from those processes.

In our study *technology* concerns the EHR that is used by physicians, nurses, and clerks (ie, the *persons*) within a university hospital (ie, the *health care organization*) located in the Netherlands. The university hospital adopted the EHR in 2015. Over 8000 hospital staff work with the EHR and all medication, blood, laboratory, and x-rays tests are ordered through the EHR. Before the university hospital implemented this EHR, a central hospital information system interfaced with multiple ancillary systems, including: a Computerized Physician Order Entry (CPOE) system for ordering medication and laboratory tests, a hospital pharmacy information system, and a hospital-wide scheduling system.

In the study, we will investigate workarounds by means of direct observations and semistructured interviews in three processes. Each process will take place in a distinct physical environment: the preparation of outpatient consultations in private offices of

health care professionals, actual outpatient consultation in examination rooms, and actual inpatient consultation with patients admitted into wards. Workarounds occurring within these three processes can have consequences that affect the outcomes of each process. We will determine the scope of each workaround to the patient, the health care professional, and the overall organization level, or a combination thereof. Furthermore, to determine the impact of each workaround, we will classify whether its consequence is favorable or unfavorable, and assess its impact on patient safety, patient care effectiveness, and efficiency.

Due to the unique nature of each health care setting to be studied, the direct observations and semistructured interview procedures will vary per setting. The research project involves six major chronological phases, as illustrated in Figure 2. The following subsections address the proposed research methods and practical execution for each phase in greater detail. A summary of the data collection and analysis plans for all three settings is provided in Table 1.

Table 1. Summary of research design by process to be studied.

Process	Preparing outpatient consultation	Providing outpatient consultation	Providing inpatient consultation
Sample	Approximately 12 physicians, 6 nurses, and 3 clerks (same staff as in *providing outpatient consultation* process)	Approximately 12 physicians, 6 nurses, and 3 clerks (same staff as in *preparing outpatient consultation* process)	Approximately 12 physicians, 6 nurses, and 3 clerks
Participant selection criteria	(1) Must have completed the required training to use EHR, and (2) must have used EHR from the moment of its implementation	(1) Must have completed the required training to use EHR, and (2) must have used EHR from the moment of its implementation	(1) Must have completed the required training to use EHR, and (2) must have used EHR from the moment of its implementation
Setting	Private office	Examination room	Inpatient ward
Interaction	User-system	User-patient, user-system	User-patient, user-system
Procedure (per person)	Direct observation while preparing outpatient consultation (1-2 hours), asking opportunistic questions while observing, semistructured follow-up interviews (1 hour)	Direct observation while providing outpatient consultation (4-6 hours), semistructured follow-up interviews (1 hour)	Direct observation during ward rounds and post-ward round EHR usage (4 hours), semistructured follow-up interviews (1 hour)
Data analysis	Transcribing and subsequent bottom-up coding of audiovisual recordings in ATLAS.ti	Transcribing and subsequent bottom-up coding of audiovisual recordings in ATLAS.ti	Transcribing and subsequent bottom-up coding of audiovisual recordings in ATLAS.ti

Figure 1. Conceptual framework to study electronic health record workarounds, adapted from Holden et al [35].

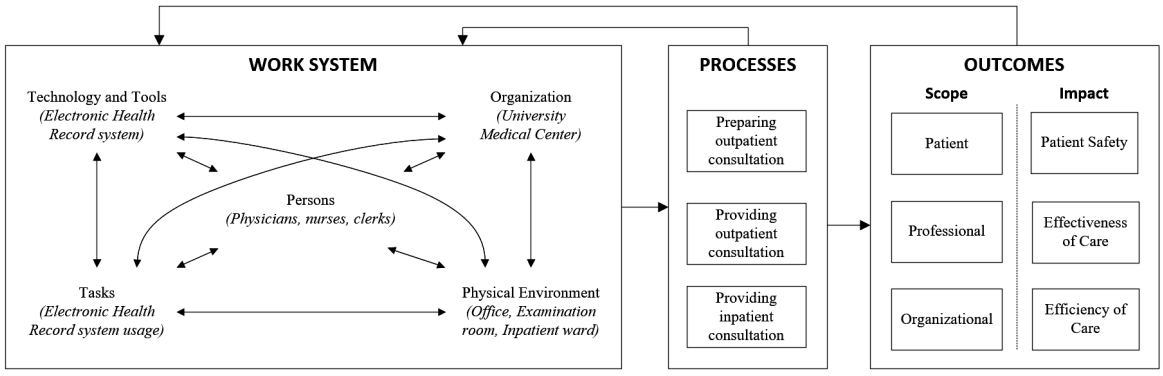
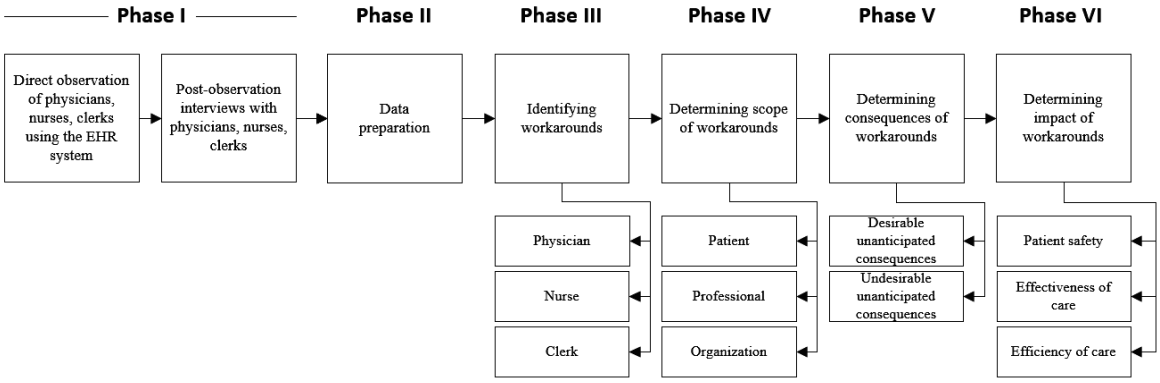


Figure 2. Illustration of the six research phases to be conducted. EHR: electronic health record.



Phase I: Data Collection

Data Collection Methods

Workarounds have been identified, analyzed, and described in various health care contexts, and in different ways; these include observations [32], interviews [20,31], focus groups [30], questionnaire surveys [33], document analyses, time and motion measures, information systems data analyses, and predominantly a combination of the foregoing methods [34]. In our study, we will apply nonparticipant direct observation in combination with semistructured post-observation interviews for two main reasons. First, workarounds must be observed *in vivo*, while work practices and EHR use by health care professionals unfold *in situ* [38]. Second, and related to the former, workarounds tend to be invisible: EHR users may not have any interest in making their workarounds explicit in interviews or surveys. In fact, if users reveal their workarounds, they could be held accountable for not complying with guidelines of system use [38].

Direct observations will be complemented with a follow-up semistructured interview with each observed health care provider. Although we will make use of an interview protocol with predefined questions that are of particular importance to maintain coherency across the cases being studied [39], not all questions will necessarily be asked in a fixed order (or asked at all). New questions may be formulated during the interviews to gather more in-depth data related to the subject being discussed, or an issue being raised by the interviewee. The questions will primarily be related to the direct observations in which the interviewee is the main actor. We therefore maintain a more flexible approach by actively probing and listening to the interviewee, known as an *open-ended interview* [40]. This approach facilitates the use of a standardized list of questions, thereby enhancing internal validity and reliability, while retaining a degree of flexibility to adapt to situational interests ad hoc [39]. Each physician, nurse, and clerk will be observed and interviewed independently. If a potentially preventable medical error occurs while observing or interviewing a participant (and only if the workaround poses a serious and direct threat, to maintain our nonparticipant approach to observation), the participant will first be asked about the reason for their workaround, and later be informed of any potential preventable medical error(s) that may result from the workaround. In addition, although an estimation of the number of physicians, nurses, and clerks to be observed and interviewed is provided in Table 1, observations and interviews will continue until the research team agrees that data saturation is achieved.

All direct observations and interviews will be captured by means of a small audiovisual camera positioned at a designated, static location (see Figure 3 for an example setup). This procedure allows us to gather raw data from health care professionals and clerks using the system from which workarounds can be identified, to pinpoint moments in the processes when workarounds occur, and conduct follow-up analyses to gain deeper insights into how and why the workaround occurred. To mitigate the Hawthorne effect during the observations and audiovisual recordings, we will clearly communicate to the participants *what is in it for them*. It will be made clear that participants have no reason to use their EHR in any different way than they normally would. First, we will explain that participating in the research project is an opportunity to improve the EHR and thereby reduce potentially negative impacts on patient safety, effectiveness, and efficiency of care. Moreover, we will stress that we will be observing the EHR rather than the participant him/herself. Second, we will clearly communicate to participants that all data gathered will be anonymous, cannot be traced back to them, and will not be shared with anyone but the research team. This approach will reassure participants that they can use their EHR as they normally would, without fear of potentially being reprimanded or rebuked afterwards. Third, the audiovisual camera will be permanently and unobtrusively installed for the duration of the observation, and does not require frequent maintenance or recalibration. Finally, observers will be positioned at a *safe distance* from the clinician using the EHR [41].

Figure 3. Example of a data collection setup in an outpatient consultation room.

The audiovisual recordings will be imported into a software application named ATLAS.ti and will be subject to further processing after this first research phase. All physicians, nurses, clerks, and patients will be asked for informed consent before any audiovisual recording takes place. The study has been proposed to, and discussed with, the chief of medical staff and the director of operations. We gained approval and support from these parties to proceed with the study, and no institutional review board approval was required. To protect patients' health information, all audiovisual recordings will be stored on an encrypted hard drive set to erase itself after a series of incorrect password entries, and subject to editing, during which any patient names or contact details will be blurred or blanked out.

Three Distinct Processes

To study the EHR from a broader perspective within the university hospital, data will be gathered within three pediatric specialties: hematology, immunology, and infectious diseases. These specialties use the same EHR, of which the *look and feel* is identical, but may use additional functionalities tailored to each specialty. Within each specialty, providers will be observed while using the system in three distinct processes: the preparation of outpatient consultation, providing outpatient consultation, and providing inpatient consultation. We will deliberately analyze multiple distinct processes to create variation with regard to physical environment in which the EHR is used, tasks performed, and outcomes produced (see Figure 1). We expect to find different types of context-dependent workarounds in each of these processes. The preparation and data collection procedures per process are explained in the following subsections.

Process 1: Preparation of Outpatient Consultation

The first process concerns health care professionals preparing outpatient visits while using the EHR in their private offices. When preparing outpatient consultations an EHR user (eg, physician or nurse) primarily relies on the availability, retrievability, and quality of the data stored in the EHR by colleagues and the user him/herself, as important clinical information is often hidden in a *sea of data* [42]. Patients will not be present in this setting and the system user will not have direct interactions with other colleagues on site, so opportunistic questions may be asked during direct observations of users interacting with the EHR. Furthermore, users will be asked to explain how they use and navigate the EHR to provide richer insight into their actions. After the observed session, a semistructured interview will be conducted with the observed user to enrich the initial observations.

Process 2: Actual Outpatient Consultation

The second process of an outpatient consultation concerns obtaining the medical history from patients, conducting a physical examination, and ordering laboratory tests or medication while a health care professional uses the EHR in a designated examination room. Since these activities are regularly carried out in a limited time frame per patient, the ratio between provider-system and provider-patient interaction demands careful balancing [43-45]. Furthermore, unexpected complexity of tasks at hand may dictate workflow or EHR-functionality

issues, may cause *no correct path* situations when a desired option does not exist in the system workflow, or spark data organization issues when a user would prefer a different overview of existing data (eg, historical patient data) [22]. Despite such issues, the user must still devise a way to accomplish his or her intentions within the given time frame; this likely gives rise to workarounds. Similar to the first process to be studied, a semistructured interview will be conducted after the observed session of the user interacting with the EHR in the presence of the patient.

Process 3: Actual Inpatient Consultation

The third and final setting concerns health care professionals using the EHR after having made inpatient ward rounds. These rounds concern regular daily reviews and consultation of hospitalized patients with regard to their medical condition, medication, and progress. Subsequently, the EHR is used to change drug prescriptions, order blood or other laboratory tests, and document the patient visit. The interface of the EHR differs from the interface shown to users in the first and second processes, thereby providing unique insights into usability-related workarounds. Similar to the first and second processes to be studied, a semistructured interview will be conducted after the observed session of the user interacting with the EHR.

Phase II: Data Preparation

Transcribing

After the data collection phase, we will transcribe the audiovisual recordings of the direct observations and interviews. We will purposefully transcribe the recordings ourselves, as this will aid in data interpretation by developing affinity with the transcriptions. Each audiovisual recording of the observations and interviews will be transcribed in a separate Microsoft Word document. These files, including the original audiovisual recordings, will be imported into ATLAS.ti as *primary documents* within a hermeneutic unit. Within these primary documents, *quotations* will be created for selected text sections or video frames possibly related to a workaround resulting from EHR usage. Quotations are independent objects without any codes assigned to them and can be regarded as bookmarks within the data set. After all transcriptions have been processed, the research team will jointly review each transcription and quotation to determine whether (1) the quotation indeed relates to a workaround of the EHR, (2) there is consistency among the quotations in terms of the range (eg, selected string length or number of video frames) of the selected data, (3) minimal discrepancies exist between the audiovisual fragments and transcribed text, and (4) to ensure no relevant sections of data were overlooked.

Bottom-Up Versus Top-Down Coding

Two approaches to coding have been considered while designing this study: *top-down* and *bottom-up*. Top-down coding would require the configuration of a set of predetermined codes from existing literature on EHR workarounds [22,28,34]. We would then simply match our data against the predetermined codes and develop new codes if a quotation would not fit in the existing classification of codes. In contrast, using bottom-up coding, we would develop the codes ourselves with the naming of codes constantly being tentative and subject to change. As more data is analyzed over time, the tentativeness of the coding taxonomy would eventually develop itself into a set of codes that fit the data well [46]. Despite being more time-demanding, we will use a bottom-up approach, as this will allow us to generate potentially new types of categories that may not emerge from a top-down approach, due to potential analytical bias (ie, forcing data into predetermined categories).

Provisional Coding Taxonomy Development

In line with a bottom-up approach, a provisional coding taxonomy will be developed by the lead researcher based on impressions and notes taken during each observation and interview, before coding of the transcriptions commences. This provisional coding taxonomy provides the coding team with a birds-eye overview of what has been witnessed during the EHR sessions with users in each of the three processes. This process will generate a temporary list of codes to be assigned to the data, to prevent each coder from developing a unique list of codes, and to ensure that coders use the same names for sections of data when their interpretations of the transcriptions are identical.

Coder Training

To establish common ground among members of the coding team before coding the transcriptions, one or multiple plenary educational sessions will be organized in which the team will be instructed on the EHR, the coding scheme, the contents of the provisional coding taxonomy, the meaning of each code, and the basics of coding in ATLAS.ti. To achieve a sufficient level of consistency and quality among coders, they will be asked to code the same copy of a random interview transcription using the provisional coding taxonomy before the actual process of coding the transcriptions starts. The copies will then be merged in ATLAS.ti to create a single analyzable file that contains all actions performed by all coders. Results will then be compared and any discrepancies or ambiguities will be discussed. If the coding scheme turns out to be ambiguous, the lead researcher will adjust the taxonomy and coding responses will be recalibrated.

Phase III: Identifying Workarounds

Open Coding

After the provisional coding taxonomy is finalized, the coding team will begin open coding. Initially, two coders will independently code five similar randomly chosen transcriptions using the provisional coding taxonomy. One or multiple codes may be assigned to each quotation. When data do not fit into codes of the provisional taxonomy, new codes may be proposed by the coders. Coders may likewise propose alternative ways of labeling the codes. The research team will then come together and compare the results of the coders. Any discrepancies related to the codes assigned for the same unit of text or video stills will be resolved through discussion. The provisional coding taxonomy will be adjusted accordingly by the lead researcher and in collaboration with the coders, if deemed necessary. Whenever the coding taxonomy is altered throughout the research project, the transcriptions that were already processed

will be reviewed again to determine whether all quotations assigned to a code still match the revised coding taxonomy. The same holds true if a code has been broken into multiple codes, or multiple codes have been merged into a single one.

We expect the tentativeness of the coding taxonomy to develop itself into a set of codes that fit the data well, after this initial round of coding. Most of the remaining transcriptions will be independently coded by the coding team. An independent reviewer will review the coded transcriptions on a regular basis and signal the research team if inconsistencies are noticed (eg, continuously using an inappropriate code for quotations with similar semantics). The research team will then resolve the inconsistencies to ensure that the predefined codes are used by all coders in the same way.

Calculating Interrater Reliability and Interrater Agreement

When all transcriptions have been coded and validated by the research team, a random sample of identical transcriptions that have been independently coded by at least two coders will be merged in ATLAS.ti. This process will create a single analyzable file containing all actions performed by all coders. Within this file, interrater reliability and interrater agreement of codes assigned to transcriptions will be calculated. We aim to do this for 30% of the transcriptions (usually 10-20% [47]). Interrater reliability will tell us whether there is consistency among the coding team with regard to selecting the same codes for the same unit of analysis (ie, quotation) while coding in isolation. Interrater agreement will tell us the extent to which coders are able to reconcile through discussion (and mediation by the independent reviewer in case the coders fail to reach consensus) if coding discrepancies arise for the same unit of analysis [48].

Tabulation

Finally, the number of quotations associated with each code will be tabulated to provide insights into which codes are more prevalent, both overall and within each of the three different health care settings. A high number of quotations associated with a given code may prompt further investigation during follow-up interviews and provide clues as to why the given code occurs more often than others.

Phase IV: Determining the Scope of Workarounds

The fourth phase aims to analyze the identified workarounds regarding their scope. As previously mentioned, each workaround will be related to its impact on the patient, the health care professional, the overall organization, or a combination thereof; this is in accordance with the *outcome* part of a process influenced by a workaround, as shown in Figure 1. Clues about which stakeholders are impacted by each workaround will primarily be gathered from the semistructured follow-up interviews. We will specifically look for responses that provide insights into the conditions that caused or influenced the workaround, the context in which it appeared, and the high-level consequences of the workaround. Any part of a response providing such insight will be stored in a separate file unique to each workaround. These files will be subject to further analyses in the following research phases.

Phase V: Determining the Consequences of EHR Workarounds

The fifth phase involves determining the consequences of each identified workaround. We have been inspired by the approach of Ash et al [49] who present a thematic hierarchical network model of consequences of CPOEs that helps in building understanding of CPOE consequences. CPOE is built upon the diffusion of innovations theory [50] and distinguishes between three classifications of outcomes: anticipated versus unanticipated, desirable versus undesirable, and direct versus indirect. We believe this model fits well with our aim of determining the impact of an EHR workaround by classifying its consequences. For our study, we are limiting ourselves to unanticipated consequences and whether each of the identified consequences is regarded as desirable or undesirable (Figure 2). We will purposefully exclude anticipated consequences of EHR workarounds from our analyses, as the focus of this study is on workarounds that are inherently suboptimal and their consequences (by definition) are not anticipated by EHR designers. Furthermore, we do not distinguish between direct versus indirect consequences of EHR workarounds since consequences of workarounds elicited by EHR use may manifest themselves in the far future rather than the near future. The following subsections define unanticipated desirable versus undesirable consequences in an EHR workaround context.

Desirable Unanticipated Consequences of EHR Workarounds

An unanticipated consequence is a consequence of an EHR workaround that has not been foreseen in advance [49]. An unanticipated consequence can be either desirable or undesirable. Desirable unanticipated consequences are unforeseen consequences that turn out to have a favorable impact on an individual or the social system in which the EHR workaround occurred; these consequences can be described as *serendipity*. In the words of Ash et al [49], these consequences can be regarded as, “happy surprises”. Examples include increased collaboration and learning from alert messages, or ordering a wrong drug purposefully to trigger the alert system to suggest the right one.

Undesirable Unanticipated Consequences of EHR Workarounds

Undesirable unanticipated consequences are unforeseen consequences that turn out to have an unfavorable impact on an individual or the social system in which the EHR workaround occurred; these consequences can be termed *unintended consequences*. Examples include health care professionals suffering from *alert fatigue* due to an overload of alerts generated by the EHR with low specificity [19,25], paper persistence [25], deteriorated communication and cooperation among health care professionals [51-53], workflow issues [25], difficulties in finding information in the system [24], never-ending system demands [25], or a human-computer interface that is unsuitable for a highly interruptive health care context [26].

Phase VI: Determining the Possible Impact of EHR Workarounds

The final phase involves determining the possible impact of EHR workaround consequences. One or multiple sessions will be organized to convene all members of the research team, health care professionals, and clerks participating in the study. The impact of each workaround consequence will then be collectively analyzed from three perspectives: patient safety, effectiveness of care, and efficiency of care.

A comprehensive list of indicators to determine the impact of EHR workaround consequences regarding the three perspectives is, to our knowledge, nonexistent. We will therefore develop a list of indicators following a bottom-up approach. Based on this list of indicators and garnered insights, our final aim is to develop a model of EHR workaround consequences and their possible impact on patient safety, effectiveness, and efficiency of care that builds upon the CPOE consequences model developed by Ash et al [49]. A concise description of the three perspectives is provided below.

Patient Safety

Patient safety is a broad discipline that has garnered increasing attention since the 1990s and has become a cornerstone of delivering high-quality health care [54]. The Institute of Medicine defines patient safety as, “the prevention of harm to patients” [55]. To tailor this definition to our context, we define patient safety as any EHR-related incident that could possibly harm one or multiple patients receiving care.

EHRs are regarded as essential to improving patient safety [7]. However, recent evidence highlights substantial and often unanticipated patient risks resulting from the use of EHRs or workarounds [34,56-58]. The safe delivery of patient care can be jeopardized by bypassing security blocks (eg, working in *emergency mode* in nonemergency situations and thereby omitting security checks) [28], cloaking deficiencies (ie, devising workarounds rather than bringing problems to the attention of systems designers, causing problems to remain hidden) [59], and undermining standardization (eg, using an alternative way to accomplish a task, thereby not conforming to a system-enforced way of working that is designed to safeguard patient safety) [60]. Understanding how consequences of EHR workarounds could impact patient safety is therefore key when formulating design and redesign interventions for EHRs.

Effectiveness of Care

According to ISO 9241-11 (1998), effectiveness can be defined as the accuracy and completeness with which users achieve specified goals [61]. Workarounds often have a negative impact on the effectiveness of user-EHR interaction; specifically, they have been found to result in information on patient care (processes) or work protocols that are unstable, unavailable, or unreliable [27]. To achieve closer alignment between work context and EHR design, it will be important to understand the impacts that workaround consequences have on the accuracy and completeness of the goals that EHR users hope to achieve.

Efficiency of Care

According to ISO 9241-11 (1998), efficiency can be defined as resources expended in relation to the accuracy and completeness with which EHR users achieve goals [61]. As previously mentioned, the ratio between provider-EHR and provider-patient interaction demands careful balancing [43-45]. Recent evidence confirms that EHRs claim a significant portion of physicians' time and draw attention away from their direct interactions with patients, and from their personal lives [62,63]. Physicians may spend 3-4 hours on EHR tasks and desk work for every hour of direct clinical time spent with patients [63]. Similar to the effectiveness of care potentially being jeopardized by workarounds, the same holds true for efficiency of care, as work protocols enforced by EHRs that are unstable, unavailable, or unreliable are sources of inefficiency [27].

Results

Data was collected using the described approach from January 2016 to March 2017. Data analysis is underway and is expected to be completed in May 2017. We aim to report the results of this study in a follow-up publication.

Discussion

Health care providers resort to informal work practices known as *workarounds* to handle exceptions to normal workflow unintentionally imposed by EHRs. Although these workarounds may seem favorable at first sight, they are generally suboptimal and may jeopardize patient safety, effectiveness, and efficiency of care. Understanding why and how workarounds occur is pivotal to developing user-friendly EHRs, and to achieve greater alignment between work context and the EHR.

Research on the scope and impact of EHR usage-related workarounds on the overall patient care processes is currently limited. Insights into the consequences of EHR workarounds on patients, health care providers, and health care organizations provide guidance on how to address EHR-related safety, effectiveness, and efficiency concerns, and to optimize EHR designs.

Our study protocol, based on the SEIPS conceptual framework [35], the thematic hierarchical network model [49], and an ethnographic approach using a combination of direct observations, semistructured interviews, and qualitative coding techniques provides a grounded framework to explore EHR workarounds from a holistic and integral perspective. More specifically, workarounds emerging from EHR use in three different health care settings will be assessed on their scope (ie, patient-, professional- or organization-related), consequences (ie, desirable versus undesirable) and impact (on patient safety, patient care effectiveness, and efficiency). Insights from this study can inform the redesign of our EHR to further align with these work contexts and subsequently lead to better organization and safer provision of care.

In addition to reporting on identified workarounds to EHR usage in an academic hospital in multiple distinct processes and settings, our final aim is to develop a model of EHR workaround consequences and their impacts on patient care that builds upon

the CPOE consequences model developed by Ash et al [49]. This model will benefit researchers and practitioners alike when analyzing EHR workarounds, and subsequently in their efforts to improve EHR design for optimal EHR usage in health care practice.

Acknowledgments

VB, KK, MJ conceived and designed the study. VB wrote the manuscript. MJ edited the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

References

1. Abramson EL, McGinnis S, Edwards A, Maniccia DM, Moore J, Kaushal R. Electronic health record adoption and health information exchange among hospitals in New York State. J Eval Clin Pract 2012 Dec;18(6):1156-1162. [doi: 10.1111/j.1365-2753.2011.01755.x] [Medline: 21914089]
2. Boonstra A, Versluis A, Vos JF. Implementing electronic health records in hospitals: a systematic literature review. BMC Health Serv Res 2014;14:370 [FREE Full text] [doi: 10.1186/1472-6963-14-370] [Medline: 25190184]
3. Robertson A, Cresswell K, Takian A, Petrakaki D, Crowe S, Cornford T, et al. Implementation and adoption of nationwide electronic health records in secondary care in England: qualitative analysis of interim results from a prospective national evaluation. BMJ 2010;341:c4564 [FREE Full text] [Medline: 20813822]
4. Henry J, Pylypchuk Y, Searcy T, Patel V. ONC Data Brief 35.: The Office of the National Coordinator for Health Information Technology; 2016 Jun. Adoption of electronic health record systems among U.S. non-federal acute care hospitals: 2008-2015 URL: https://www.healthit.gov/sites/default/files/briefs/2015_hospital_adoption_db_v17.pdf [accessed 2017-04-10] [WebCite Cache ID 6pcicpUjJ]
5. Angst C, Agarwal R. Adoption of electronic health records in the presence of privacy concerns: the elaboration likelihood model and individual persuasion. MIS Q 2009;33(2):339-370.
6. Bates DW, Gawande AA. Improving safety with information technology. N Engl J Med 2003 Jun 19;348(25):2526-2534. [doi: 10.1056/NEJMsa020847] [Medline: 12815139]
7. Blumenthal D, Glaser JP. Information technology comes to medicine. N Engl J Med 2007 Jun 14;356(24):2527-2534. [doi: 10.1056/NEJMhpr066212] [Medline: 17568035]
8. Hollingworth W, Devine EB, Hansen RN, Lawless NM, Comstock BA, Wilson-Norton JL, et al. The impact of e-prescribing on prescriber and staff time in ambulatory care clinics: a time motion study. J Am Med Inform Assoc 2007;14(6):722-730 [FREE Full text] [doi: 10.1197/jamia.M2377] [Medline: 17712088]
9. King J, Patel V, Jamoom EW, Furukawa MF. Clinical benefits of electronic health record use: national findings. Health Serv Res 2014 Feb;49(1 Pt 2):392-404 [FREE Full text] [doi: 10.1111/1475-6773.12135] [Medline: 24359580]
10. Miller RH, West C, Brown TM, Sim I, Ganchoff C. The value of electronic health records in solo or small group practices. Health Aff (Millwood) 2005;24(5):1127-1137 [FREE Full text] [doi: 10.1377/hlthaff.24.5.1127] [Medline: 16162555]
11. Cebul RD, Love TE, Jain AK, Hebert CJ. Electronic health records and quality of diabetes care. N Engl J Med 2011 Sep 1;365(9):825-833. [doi: 10.1056/NEJMsa1102519] [Medline: 21879900]
12. Cheriff AD, Kapur AG, Qiu M, Cole CL. Physician productivity and the ambulatory EHR in a large academic multi-specialty physician group. Int J Med Inform 2010 Jul;79(7):492-500. [doi: 10.1016/j.ijmedinf.2010.04.006] [Medline: 20478738]
13. Carrington JM, Effken JA. Strengths and limitations of the electronic health record for documenting clinical events. Comput Inform Nurs 2011 Jun;29(6):360-367. [doi: 10.1097/NCN.0b013e3181fc4139] [Medline: 21107239]
14. Goetz Goldberg D, Kuzel AJ, Feng LB, DeShazo JP, Love LE. EHRs in primary care practices: benefits, challenges, and successful strategies. Am J Manag Care 2012 Feb;18(2):e48-e54 [FREE Full text] [Medline: 22435884]
15. Howard J, Clark EC, Friedman A, Crosson JC, Pellerano M, Crabtree BF, et al. Electronic health record impact on work burden in small, unaffiliated, community-based primary care practices. J Gen Intern Med 2013 Jan;28(1):107-113 [FREE Full text] [doi: 10.1007/s11606-012-2192-4] [Medline: 22926633]
16. Zlabek JA, Wickus JW, Mathiason MA. Early cost and safety benefits of an inpatient electronic health record. J Am Med Inform Assoc 2011;18(2):169-172 [FREE Full text] [doi: 10.1136/jamia.2010.007229] [Medline: 21292703]
17. Adler-Milstein J, Salzberg C, Franz C, Orav EJ, Newhouse JP, Bates DW. Effect of electronic health records on health care costs: longitudinal comparative evidence from community practices. Ann Intern Med 2013 Jul 16;159(2):97-104. [doi: 10.7326/0003-4819-159-2-201307160-00004] [Medline: 23856682]
18. Abramson EL, Patel V, Malhotra S, Pfoh ER, Nena OS, Cheriff A, et al. Physician experiences transitioning between an older versus newer electronic health record for electronic prescribing. Int J Med Inform 2012 Aug;81(8):539-548. [doi: 10.1016/j.ijmedinf.2012.02.010] [Medline: 22465355]

19. Carspecken CW, Sharek PJ, Longhurst C, Pageler NM. A clinical case of electronic health record drug alert fatigue: consequences for patient outcome. Pediatrics 2013 Jun;131(6):e1970-e1973 [FREE Full text] [doi: 10.1542/peds.2012-3252] [Medline: 23713099]
20. Saleem JJ, Russ AL, Justice CF, Hagg H, Ebright PR, Woodbridge PA, et al. Exploring the persistence of paper with the electronic health record. Int J Med Inform 2009 Sep;78(9):618-628. [doi: 10.1016/j.ijmedinf.2009.04.001] [Medline: 19464231]
21. Saleem JJ, Russ AL, Neddo A, Blades PT, Doebbeling BN, Foresman BH. Paper persistence, workarounds, and communication breakdowns in computerized consultation management. Int J Med Inform 2011 Jul;80(7):466-479. [doi: 10.1016/j.ijmedinf.2011.03.016] [Medline: 21530383]
22. Flanagan ME, Saleem JJ, Millitello LG, Russ AL, Doebbeling BN. Paper- and computer-based workarounds to electronic health record use at three benchmark institutions. J Am Med Inform Assoc 2013 Jun;20(e1):e59-e66 [FREE Full text] [doi: 10.1136/amiajnl-2012-000982] [Medline: 23492593]
23. Zandieh SO, Yoon-Flannery K, Kuperman GJ, Langsam DJ, Hyman D, Kaushal R. Challenges to EHR implementation in electronic- versus paper-based office practices. J Gen Intern Med 2008 Jun;23(6):755-761 [FREE Full text] [doi: 10.1007/s11606-008-0573-5] [Medline: 18369679]
24. Ash JS, Gorman PN, Lavelle M, Payne TH, Massaro TA, Frantz GL, et al. A cross-site qualitative study of physician order entry. J Am Med Inform Assoc 2003;10(2):188-200 [FREE Full text] [Medline: 12595408]
25. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. J Am Med Inform Assoc 2006;13(5):547-556 [FREE Full text] [doi: 10.1197/jamia.M2042] [Medline: 16799128]
26. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. J Am Med Inform Assoc 2004 Apr;11(2):104-112 [FREE Full text] [doi: 10.1197/jamia.M1471] [Medline: 14633936]
27. Kobayashi M, Fussell S, Xiao Y, Seagull F. Work coordination, workflow,workarounds in a medical context. In: CHI '05 Extended Abstracts on Human Factors in Computing Systems. New York, NY, USA: ACM; 2005 Presented at: Conference on Human Factors in Computing Systems; 02-07-2015; Portland, OR, USA p. 1561-1564. [doi: 10.1145/1056808.1056966]
28. Koppel R, Wetterneck T, Telles JL, Karsh B. Workarounds to barcode medication administration systems: their occurrences, causes, and threats to patient safety. J Am Med Inform Assoc 2008;15(4):408-423 [FREE Full text] [doi: 10.1197/jamia.M2616] [Medline: 18436903]
29. Ash JS, Sittig DF, Seshadri V, Dykstra RH, Carpenter JD, Stavri PZ. Adding insight: a qualitative cross-site study of physician order entry. Int J Med Inform 2005 Aug;74(7-8):623-628 [FREE Full text] [doi: 10.1016/j.ijmedinf.2005.05.005] [Medline: 15964780]
30. McAlearney AS, Vrontos J, Schneider PJ, Curran CR, Czerwinski BS, Pedersen CA. Strategic work-arounds to accommodate new technology. J Patient Saf 2007;3(2):75-81. [doi: 10.1097/01.jps.0000242987.93789.63]
31. Saleem J, Russ A, Justice C, Hagg H, Woodbridge P, Doebbeling B. Paper use with the electronic medical record: an important supplement or negative circumvention? In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2008 Sep 01 Presented at: 52nd Human Factors and Ergonomics Society Annual Meeting, HFES 2008; September 1, 2008; New York, NY, USA p. 773-777. [doi: 10.1177/154193120805201202]
32. Mazur LM, Chen S. An empirical study for medication delivery improvement based on healthcare professionals' perceptions of medication delivery system. Health Care Manag Sci 2009 Mar;12(1):56-66. [Medline: 19938442]
33. Wheeler AR, Halbesleben JR, Harris KJ. How job-level HRM effectiveness influences employee intent to turnover and workarounds in hospitals. J Bus Res 2012 Apr;65(4):547-554. [doi: 10.1016/j.jbusres.2011.02.020]
34. Debono DS, Greenfield D, Travaglia JF, Long JC, Black D, Johnson J, et al. Nurses' workarounds in acute healthcare settings: a scoping review. BMC Health Serv Res 2013;13(175) [FREE Full text] [doi: 10.1186/1472-6963-13-175] [Medline: 23663305]
35. Holden RJ, Carayon P, Gurses AP, Hoonakker P, Hundt AS, Ozok AA, et al. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics 2013;56(11):1669-1686 [FREE Full text] [doi: 10.1080/00140139.2013.838643] [Medline: 24088063]
36. Donabedian A. The quality of care. How can it be assessed? JAMA 1988;260(12):1743-1748. [Medline: 3045356]
37. Hysong SJ, Sawhney MK, Wilson L, Sittig DF, Esquivel A, Watford M, et al. Improving outpatient safety through effective electronic communication: a study protocol. Implement Sci 2009;4(62) [FREE Full text] [doi: 10.1186/1748-5908-4-62] [Medline: 19781075]
38. Cabitza F, Simone C. “Drops Hollowing the Stone”: Workarounds as Resources for Better Task-Artifact Fit. London: Springer; 2013 Sep Presented at: ECSCW 2013: 13th European Conference on Computer Supported Cooperative Work; September 2013; Paphos, Cyprus p. 13-22. [doi: 10.1007/978-1-4471-5346-7_6]
39. Yin R. Case study Research: Design and Methods. Thousand Oaks, CA, USA: Sage; 2013.
40. Silverman D. Interpreting Qualitative Data: Methods for Analyzing Talk, Text and Interaction. London, UK: Sage Publications Ltd; 2006.

41. Yen K, Shane E, Pawar S, Schwendel N, Zimmanck R, Gorelick M. Time motion study in a pediatric emergency department before and after computer physician order entry. Ann Emerg Med 2009 Apr;53(4):462-468.e1. [doi: 10.1016/j.annemergmed.2008.09.018] [Medline: 19026466]
42. Wang CJ, Huang AT. Integrating technology into health care: what will it take? JAMA 2012 Feb 8;307(6):569-570. [doi: 10.1001/jama.2012.102] [Medline: 22318276]
43. Margalit RS, Roter D, Dunevant MA, Larson S, Reis S. Electronic medical record use and physician-patient communication: an observational study of Israeli primary care encounters. Patient Educ Couns 2006 Apr;61(1):134-141. [doi: 10.1016/j.pec.2005.03.004] [Medline: 16533682]
44. Chan W, Stevenson M, McGlade K. Do general practitioners change how they use the computer during consultations with a significant psychological component? Int J Med Inform 2008 Aug;77(8):534-538. [doi: 10.1016/j.ijmedinf.2007.10.005] [Medline: 18036885]
45. White A, Danis M. Enhancing patient-centered communication and collaboration by using the electronic health record in the examination room. JAMA 2013 Jun 12;309(22):2327-2328 [FREE Full text] [doi: 10.1001/jama.2013.6030] [Medline: 23757080]
46. Glaser B, Strauss A. The discovery of grounded theory; strategies for qualitative research. Chicago: Aldine Publiching; 1999.
47. Joffe H. Thematic analysis. In: Qualitative Research Methods in Mental Health and Psychotherapy. Chichester, UK: John Wiley & Sons, Ltd; 2011:209-223.
48. Campbell JL, Quincy C, Osserman J, Pedersen OK. Coding in-depth semistructured interviews: problems of unitization and intercoder reliability and agreement. Socio Meth Res 2013 Aug 21;42(3):294-320. [doi: 10.1177/0049124113500475]
49. Ash JS, Sittig DF, Dykstra RH, Guappone K, Carpenter JD, Seshadri V. Categorizing the unintended sociotechnical consequences of computerized provider order entry. Int J Med Inform 2007 Jun;76 Suppl 1:S21-S27. [doi: 10.1016/j.ijmedinf.2006.05.017] [Medline: 16793330]
50. Rogers E. Diffusion of Innovations, 5th Edition. New York, NY, USA: Free Press; 2003.
51. Parker J, Coiera E. Improving clinical communication: a view from psychology. J Am Med Inform Assoc 2000;7(5):453-461 [FREE Full text] [Medline: 10984464]
52. Shu K, Boyle D, Spurr C, Horsky J, Heiman H, O'Connor P, et al. Comparison of time spent writing orders on paper with computerized physician order entry. Stud Health Technol Inform 2001;84(Pt 2):1207-1211. [Medline: 11604922]
53. Dykstra R. Computerized physician order entry and communication: reciprocal impacts. 2002 Presented at: Proceedings of the AMIA Symposium; 2002; San Antonio, TX, USA p. 230-234 URL: http://europepmc.org/abstract/MED/12463821
54. Emanuel L, Berwick D, Conway J, Combes J, Hatlie M, Leape L, et al. What exactly is patient safety? In: Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 1: Assessment). Rockville, MD, USA: Agency for Healthcare Research and Quality; 2008.
55. Aspden P, Corrigan J, Wolcott J, Erickson S. Achieving a New Standard for Care. Washington, DC, USA: The National Academy of Sciences; 2004.
56. Harrington L, Kennerly D, Johnson C. Safety issues related to the electronic medical record (EMR): synthesis of the literature from the last decade, 2000-2009. J Healthc Manag 2011;56(1):31-43. [Medline: 21323026]
57. Institute of Medicine. Health IT and Patient Safety: Building Safer Systems for Better Care. Washington, DC, USA: National Academies Press; 2011.
58. Warm D, Edwards P. Classifying health information technology patient safety related incidents - an approach used in Wales. Appl Clin Inform 2012;3(2):248-257 [FREE Full text] [doi: 10.4338/ACI-2012-03-RA-0010] [Medline: 23646074]
59. Tucker AL, Edmondson AC, Spear S. When problem solving prevents organizational learning. J Organ Change Manag 2002 Apr;15(2):122-137. [doi: 10.1108/09534810210423008]
60. Whooley O. Diagnostic ambivalence: psychiatric workarounds and the Diagnostic and Statistical Manual of Mental Disorders. Sociol Health Illn 2010 Mar;32(3):452-469 [FREE Full text] [doi: 10.1111/j.1467-9566.2010.01230.x] [Medline: 20415790]
61. International Organization for Standardization. Part 11: guidance on usability. In: Ergonomic requirements for office work with visual display terminals (VDTs). Geneva, Switzerland: International Organization for Standardization; 1998.
62. Hingle S. Electronic health records: an unfulfilled promise and a call to action. Ann Intern Med 2016 Dec 06;165(11):818-819. [doi: 10.7326/M16-1757] [Medline: 27595501]
63. Sinsky C, Colligan L, Li L, Prgomet M, Reynolds S, Goeders L, et al. Allocation of physician time in ambulatory practice: a time and motion study in 4 specialties. Ann Intern Med 2016 Dec 06;165(11):753-760. [doi: 10.7326/M16-0961] [Medline: 27595430]

Abbreviations

CPOE: Computerized Physician Order Entry
EHR: Electronic Health Record
SEIPS: Systems Engineering Initiative for Patient Safety

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Protocol

Protocol of a Pilot Study of Technology-Enabled Coproduction in Pediatric Chronic Illness Care

Heather C Kaplan[1,2*], MD, MSCE; Sunny Narendra Thakkar[1], BA; Lisa Burns[3], MD; Barbara Chini[3], MD; Dana MH Dykes[4], MD; Gary L McPhail[3], MD; Erin Moore[1], BS; Shehzad Ahmed Saeed[5], MD; Ian Eslick[6], PhD; Peter A Margolis[1], MD, PhD; Lisa Opipari-Arrigan[1,7*], PhD

[1]Cincinnati Children's Hospital Medical Center, James M. Anderson Center for Health Systems Excellence, Cincinnati, OH, United States

[2]Cincinnati Children's Hospital Medical Center, Perinatal Institute, Cincinnati, OH, United States

[3]Cincinnati Children's Hospital Medical Center, Division of Pulmonary Medicine, Cincinnati, OH, United States

[4]Cincinnati Children's Hospital Medical Center, Division of Gastroenterology, Hepatology, & Nutrition, Cincinnati, OH, United States

[5]Dayton Children's Hospital, Department of Gastroenterology and Nutrition, Dayton, OH, United States

[6]Vital Labs, Inc., San Francisco, CA, United States

[7]Cincinnati Children's Hospital Medical Center, Behavioral Medicine & Clinical Psychology, Cincinnati, OH, United States

[*]these authors contributed equally

Corresponding Author:
Heather C Kaplan, MD, MSCE
Cincinnati Children's Hospital Medical Center
James M. Anderson Center for Health Systems Excellence
3333 Burnet Avenue, MLC 7009
Cincinnati, OH, 45229
United States
Phone: 1 513 803 0478
Fax: 1 513 636 0171
Email: heather.kaplan@cchmc.org

Abstract

Background: Pediatric chronic illness care models are traditionally organized around acute episodes of care and may not meet the needs of patients and their families. Interventions that extend the patient-clinician interaction beyond the health care visit, allow for asynchronous and bidirectional feedback loops that span visits and daily life, and facilitate seamless sharing of information are needed to support a care delivery system that is more collaborative, continuous, and data-driven. Orchestra is a mobile health technology platform and intervention designed to transform the management of chronic diseases by optimizing patient-clinician coproduction of care.

Objective: The aim of this study is to assess the feasibility, acceptability, and preliminary impact of the Orchestra technology and intervention in the context of pediatric chronic illness care.

Methods: This study will be conducted in the cystic fibrosis and inflammatory bowel disease clinics at Cincinnati Children's Hospital Medical Center. We will enroll interested patients and their caregivers to work with clinicians to use the Orchestra technology platform and care model over a 6-month period. In parallel, we will use quality improvement methods to improve processes for integrating Orchestra into clinic workflows and patient/family lifestyles. We will use surveys, interviews, technology use data, and measures of clinical outcomes to assess the feasibility, acceptability, and preliminary impact of Orchestra. Outcome measures will include assessments of: (1) enrollment and dropout rates; (2) duration of engagement/sustained use; (3) symptom and patient-reported outcome tracker completion rates; (4) perceived impact on treatment plan, communication with the clinical team, visit preparation, and overall care; (5) changes in disease self-efficacy and engagement in care; and (6) clinical outcomes and health care utilization.

Results: Participant recruitment began in mid-2015, with results expected in 2017.

Conclusions: Chronic disease management needs a dramatic transformation to support more collaborative, effective, and patient-centered care. This study is unique in that it is testing not only the impact of technology, but also the necessary processes that facilitate patient and clinician collaboration. This pilot study is designed to examine how technology-enabled coproduction

can be implemented in real-life clinical contexts. Once the Orchestra technology and intervention are optimized to ensure feasibility and acceptability, future studies can test the effectiveness of this approach to improve patient outcomes and health care value.

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KEYWORDS

mobile applications; chronic disease; physician-patient relationship; cystic fibrosis; inflammatory bowel disease

Introduction

Effective management of chronic illness requires a different type of health care delivery system than presently exists [1]. Our current models of care, which are organized around treating acute episodic conditions, do not meet the needs of the growing number of patients with serious, chronic health problems [2,3]. Typically, individuals with chronic illness are seen by their specialist a few times a year. During these brief visits, patients and families are expected to identify, remember, and communicate to the clinical team the most relevant aspects of their illness experience from the previous weeks or months. Clinicians are then charged with gathering enough detail from the information shared by patients and families to make optimal treatment recommendations. Traditional clinic visits provide the clinician with only a blurry and fleeting snapshot of a patient's disease [4]. The experience is similar for patients and families, who generally lack access to clinical data and test results and, even when results are made available, they are not accompanied by understandable explanations. These issues hamper patients' ability to fully participate in decision-making [4].

While the clinical encounter is a valuable interaction, its design does not support optimal patient engagement, clinician efficiency and effectiveness, or health outcomes [1,3-5]. To improve the clinical encounter, we need ways to: (1) easily extend patient-clinician interaction beyond the circumscribed visit; (2) allow for asynchronous, bidirectional feedback loops that span both visits and daily life; (3) regularly collect and monitor patient-reported data between visits; and (4) seamlessly share clinically-generated and patient-generated information [2,4]. In addition, patients and clinicians need support to truly coproduce care, allowing them to collaborate to produce *information* (eg, clinical data, patient-reported outcomes [PROs]), *knowledge* (insights), and *know-how* (expertise) to improve health care and health outcomes [1,3-5].

Technology can help to address these gaps by enabling low-friction data collection, sharing, and communication [3,6-8]. An increasing number of technologies designed to support chronic disease management are being developed. A recent study of an electronic health record (EHR)-linked patient portal to track family treatment concerns, goals, symptoms, medication side-effects, and adherence in pediatric asthma showed promise for improving communication, self-management, and outcomes [9]. In addition, there is an exponential rise in reports of apps being developed to support better chronic disease management in diabetes [10-12], hypertension [13], chronic pain [14]. However, technology is only part of the solution. A recent systematic review that examined the effectiveness of mobile health (mHealth) in supporting chronic disease management found mixed results [15]. The authors concluded that while the potential for improved outcomes is high, more work is needed to focus on how technology is implemented in ways that overcome existing barriers [15]. Technology alone will have minimal impact on chronic disease management unless it is seamlessly integrated into patients' lives and clinicians' workflows in a way that relieves burdens and addresses unmet needs [6,7].

Orchestra is an mHealth technology platform (mobile, tablet, desktop) and intervention designed with and for patients, families, and clinicians to facilitate coproduction of care. Orchestra is aimed at transforming the management of chronic disease by making care more collaborative, continuous, and effective. Orchestra emerged from goal-directed design work conducted as part of the development of a collaborative chronic care network for pediatric inflammatory bowel disease (IBD) [16]. Interviews and direct observations led to the creation of personas and scenarios that were used to derive requirements of an improved chronic care system. The personas and scenarios guided the generation of 100 prototype interventions designed to address these requirements. Among these prototypes were: (1) the Personalized Learning System [17], a Web-based and short messaging system (SMS) technology platform that enabled patients with chronic diseases to work collaboratively with their clinicians to identify issues of importance to them, track outcomes, and learn from both routine changes in everyday life (eg, diet changes, sleep patterns) and formal planned experiments; and (2) the E^3(Engaged, Empowered, Electronic) Healthcare Study [18], which developed and tested mobile and Web-based tools, including a previsit planner and weekly symptom tracker designed to optimize clinical interactions and shared decision-making. Observations and learnings from these two prototypes were used to inform the design and development of the Orchestra technology platform and intervention.

The aim of this pilot study is to assess the feasibility, acceptability, and preliminary impact of Orchestra in the context of pediatric chronic illness, while simultaneously developing and refining the processes that allow for integration into the care delivery system [19].

Methods

Study Setting

This study is being conducted in the Cystic Fibrosis (CF) Center and IBD clinic at Cincinnati Children's Hospital Medical Center (CCHMC). CCHMC is a 629-bed children's hospital with associated ambulatory clinics, and is the only children's hospital in the Cincinnati metropolitan area (population 2.3 million). The CF clinic within the pulmonology division cares for approximately 225 patients with CF and is one of 10 CF

Foundation Research Centers in the United States. The Schubert Martin IBD Center cares for approximately 700 patients with Crohn's disease and ulcerative colitis, and is home to a wide array of cutting-edge basic and translational research. Both clinics are staffed with multidisciplinary teams that include psychology, nutrition, and social work. CCHMC uses Epic (Verona, Wisconsin) as its EHR.

Project Timeline

The development of the Orchestra technology and intervention has proceeded through a series of small pilot studies, using a rapid iteration process. The first phase of pilot testing was designed to refine the technology (June to December 2014). The platform was tested with 4 physicians, 17 patients, and 31 caregivers. The current phase of testing (phase 2) is designed to: increase the number and type of clinicians involved (physicians, nurses, dietitians, social workers, psychologist, and respiratory therapists); increase the number of patients using Orchestra; refine the processes necessary to integrate Orchestra into patients' lives and clinicians' workflows; and measure the feasibility, acceptability, and impact of the Orchestra intervention when used over a 6-month period. Phase 2 aims to enroll 100 participants.

Study Intervention

Overview

The Orchestra technology and intervention is designed to: (1) extend clinical data sharing and decision-making beyond the circumscribed clinic visit by allowing ongoing, asynchronous, and bidirectional symptom monitoring and feedback loops between clinicians and patients; (2) support patients and clinicians in preparing for the clinic visit and having the right information at the right time so that they can effectively collaborate, communicate, and codesign a care plan that works; (3) prepare patients and clinicians to be equal partners in a culture of medicine in which they have not been trained to do this; (4) transform the valuable time spent during the clinic visit from information transfer based on ambiguous memory and limited recall to data-based problem-solving that addresses patient and family goals; and (5) support patients and clinicians in using data, quality improvement methods, and planned experimentation to learn about which treatments and lifestyle modifications help them feel better. Screenshots of the Orchestra technology components are provided in Multimedia Appendix 1.

Technology Components

Symptom Tracking and Journal/Note Entry

This feature allows patients/caregivers to regularly track symptoms, health behaviors, and standardized multi-item PRO measures between clinic visits. Frequency of data tracking can range from daily to weekly, based on the specific measure and the schedule agreed upon by the patient/caregiver and clinician. Tracking is done on the mobile app or the desktop platform and can be prompted through push notification, SMS, and/or email. Tracked symptoms are depicted via line graphs and are viewable in real-time by patient/caregiver and clinician. Patient/caregiver and clinician can attach a note to a specific data point and can capture general thoughts in journal entries. Notes and journals are designed to document observations about the data that facilitate learning from variation and natural experiments (eg, impact of travel or a diet change) and enhance communication. Symptom tracking is meant to improve clarity regarding the patient's condition and refine hypotheses about changes that might improve the patient's symptoms. Examples of participants' symptom trackers are provided in Multimedia Appendix 2.

Automated Signals for Changes in Patient Status

Clinicians are notified of changes in a patient's symptoms when certain preestablished criteria are met. This feature is meant to alert clinicians to data that is potentially actionable. Clinicians can enable and customize automated signals for each individual measure being tracked by the participant. Data signals are sent to clinicians via email and generated using two distinct methods. The statistical process control (SPC) option generates signals by using statistical algorithms to identify significant changes in the individual measures. Once a sufficient amount of baseline data has been entered by the participant (usually the first 20 data entries) [20], it is continuously analyzed using SPC rules to identify significant changes. Alternatively, the threshold option employs user-defined formulas to signal clinicians if established criteria are met (eg, if frequency of coughing is greater than *most of the day* for more than three days in a row). By default, measures are set up with signals turned off. Clinicians have the option of enabling one or both types of signals on measures that are key symptom indicators of a patient's health status. At this time, patients and caregivers are not notified of signals.

The Previsit Plan

A previsit plan (PVP) is pushed to the patient's/caregiver's account two weeks prior to a clinic appointment, and consists of two components: (1) a health metric review with personalized feedback, and (2) a previsit survey. In the health metric review, laboratory and other relevant health metrics from the previous 12 months (obtained from the HER) are displayed using intuitive visualizations and plain language to help patients/caregivers understand the meaning of their results and health trends. Results are accompanied by personalized suggestions of topics to address during the clinical encounter, based on the results. This component contains health metrics specific to the relevant chronic condition. For example, in IBD key metrics include variables such as hematocrit, serum albumin, height, weight, body mass index (BMI), and physician global assessment of disease activity. CF key metrics include the percent predicted Forced Expiratory Volume in 1 second (FEV1) and BMI percentile. The previsit survey graphically depicts all responses to tracked data during the intervisit period, prompts the patient/caregiver to respond to a set of questions related to current symptoms and functioning, provides the patient/caregiver with an opportunity to review all notes and journal entries recorded during the intervisit period and select the ones that the participant would like to discuss with their clinicians, and solicits goals for the upcoming visit. The previsit survey, once complete, is viewable in real time by the patient/caregiver and by the clinician. The clinician view includes flagging of responses outside of normal limits.

Planned Experimentation

Patients/caregivers and clinicians are supported in using quasi-experimental or experimental designs to learn from data tracking and test hypotheses. Experimental designs can range from simple pre/post designs to more formal N-of-1 studies using multiple cross-over designs. Participants and clinicians work together to test hypotheses related to starting new medications or making diet and lifestyle changes.

Clinician Portal

Clinicians view their Orchestra patients via a Web-based portal. Clinicians can access the portal, using one-click single-sign-on authentication through the EHR, to support seamless workflow integration. A basic population panel includes patient name, age, gender, names of individuals tracking (patient and/or caregiver), and date of the next scheduled visit (pulled from the EHR). The population panel enables simple hierarchical sorting of patients by clinician, care team, and clinic, and serves as the gateway to accessing detailed symptom-tracking graphs, journals/notes, and PVPs.

Intervention Components

Shared Decision-Making Regarding Goal for Use

As a participant is introduced to Orchestra, the clinician guides a collaborative discussion with the patient/caregiver about identifying a clear purpose for how Orchestra will be used to benefit the patient's care, and which are the best measures to track, in order to achieve the shared goal.

Establishment of a Social Contract

As a participant is introduced to Orchestra, the clinician guides a discussion on how often the clinical team will look at the data. The *social contract* supports expectation-setting around frequency of communication, helps participants understand that the clinical team values the data and is looking at data during the intervisit period, and supports clinicians in using the platform during the intervisit period .

Reinforcing Use During Intervisit Period

Clinicians review all data signals during the intervisit period and reach out to the patient/caregiver as appropriate. Clinicians are encouraged to review and refer to Orchestra data prior to or during any intervisit phone or email communication with a patient/caregiver. Clinicians are encouraged to incorporate the PVP into their preclinic planning process in order to be apprised of the patient's current status, and be prepared to address patient goals at the visit. In addition, clinicians are encouraged to use the Orchestra journaling feature to leave notes of encouragement related to system use for participants.

Collaborative Review of Tracked Data and Previsit Plan at Clinic Visits

Clinicians are encouraged to refer to Orchestra tracker data and the PVP during the clinical encounter to make the patient/caregiver aware that they have reviewed the data and that it is contributing to clinical decision making, and to reinforce system use. Clinicians are also encouraged to jointly review the Orchestra graphs with patients/caregivers during the encounter as a tool for education and collaboration.

Study Population

Participants are eligible for the study if they (1) are able to speak/read English, (2) have a clinical diagnosis of CF or IBD, (3) are between the ages of 14 and 21 years and/or are parents or legal guardians of patients between the ages of birth and 21 years, (4) have a smartphone or tablet device with compatible iOS or Android operating system, (5) have a mobile data plan and/or Internet connection, (6) have at least two clinic visits during the period of tool deployment (one at study entry, and at least one subsequent visit within 6 months), and (7) do not have a comorbid disorder that prohibits participation.

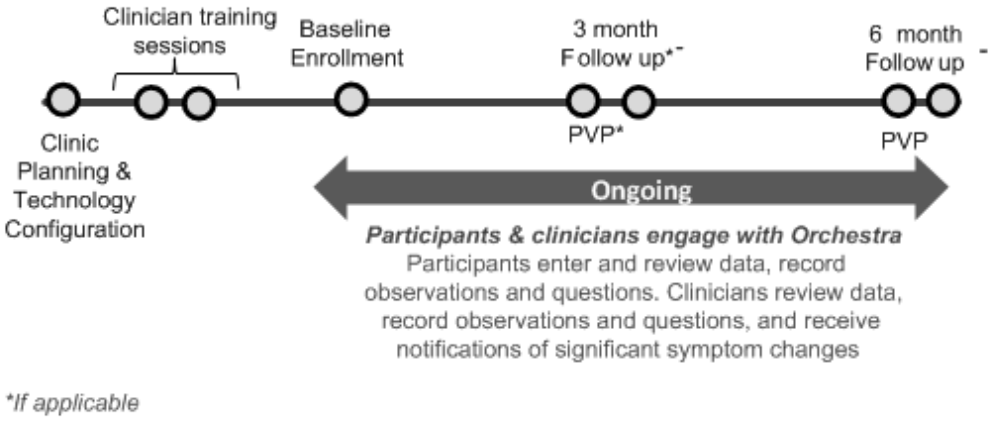
Ethics

The protocol, all research staff, and all patient-facing materials related to the study were approved by the Institutional Review Board (IRB) at CCHMC. Data security was addressed as part of the IRB review and is managed in three ways. First, the Orchestra platform is hosted on a cluster of dedicated machines isolated within a virtual private cloud (VPC). Second, data are fully encrypted in transit between machines within the VPC. Simple messages that do not carry protected health information (PHI) are sent by the system, and unidentifiable numeric responses are typically returned. The only PHI involved in the transaction is the phone number or unique identification (ID) used to identify the participant's phone. Participants are able to opt out of these mechanisms and respond entirely through a secure website if they choose. Third, the Orchestra platform makes selective, secure connections to CCHMC Web services for the specific purposes of gathering laboratory values and visit-scheduling information, and registering new participants. Registration activities pass a short set of personal identifiers (eg, name, date of birth, and cell phone number) to the platform and the platform returns a unique ID to Epic, which is used to open the platform within Epic and access laboratory data.

Study Procedures

This is a prospective, single group, pre/post pilot study. Study procedures are summarized in Figure 1 and are broken down into the following phases: *Clinic Planning*, *Clinician Onboarding and Training*, *Participant In-Clinic Training and Onboarding (Baseline Visit)*, *Intervisit Period*, *Follow-Up Visits*, *Ongoing Process Improvements for Integrating Orchestra in the Clinic*, and *Technology Support.*

Figure 1. Study Procedures.



Clinic Planning

Select clinicians in the CF and IBD clinics (ie, clinician champions) partnered with the research team to develop a standard, condition-specific catalogue of relevant measures for participants to track. Validated measures were used when available; otherwise new questions were written to assess relevant symptoms and behaviors. Measures were preloaded into the Orchestra platform for ease of tracker selection and set up. Clinical champions selected the previsit survey questions and health metrics for the PVP, developed text for clinical algorithms that describe what each health metric means, and suggested topics based on the patient's results to discuss at the visit. The planning phase also included the development of process maps defining how Orchestra integrates into clinic visits and intervisit workflows, including when and how potential participants are introduced to the study, how clinicians work with their patients/families to select trackers, when and how patients are set up and oriented to the Orchestra technology, and how Orchestra data are integrated into the care process to facilitate coproduction.

Clinician Onboarding and Training

All clinicians that cared for patients, including physicians, nurses, dietitians, respiratory therapists, and social workers, received training on the use of Orchestra. Two 90-minute, condition-specific, in-person training sessions were conducted. Training included instructions on how to use the Orchestra technology platform and how to incorporate the Orchestra intervention into patient care. Clinicians received individual accounts with clinic-level access to the Orchestra platform that allowed them to access all patients using Orchestra in their clinic.

Participant In-Clinic Training and Onboarding (Baseline Visit)

Three main methods of study recruitment are employed, and the recruitment method varies depending on the clinic flow and scheduling. Eligible participants are either identified and contacted by study and/or clinic staff prior to an upcoming appointment or, if not contacted in advance, approached in-person at the clinic appointment. Recruitment is completed with interested participants at the clinic visit. Research staff meets with all interested caregivers and patients to review and complete informed consent. Assent is obtained from all children aged 14-17 who are participating in the study. Consent is obtained from parents (or legal guardians) or study participants who are 18 years of age or older.

After clinic check-in, eligible participants are shown a 2-minute introductory video designed to spark interest in using Orchestra. This video focuses on inspiring patients to visualize a redesigned approach to care. Research coordinators (RCs) initiate study enrollment and inform the clinical team of a patient's/caregiver's interest in using Orchestra. During the clinical encounter, participants collaborate with their clinicians to identify goals for Orchestra use and select trackers and tracker frequency (eg, daily, weekly, other). Upon completion of the visit, clinicians independently decide whether to set data signals, and the type of signal to set (SPC and/or threshold), on any of the selected trackers in order to be alerted to a change in patient status.

After the clinical encounter, the RC meets with the participant to complete baseline surveys. The RC creates an Orchestra participant account via administrator functionality on the platform and supports the participant in downloading and setting up the app on their mobile device before they leave the clinic. After installation, the RC ensures that the account is functioning correctly and the participant is comfortable with basic app use. The app was developed with strong user interface design principles, and we anticipate that minimal training will be necessary to ensure patients can use the Orchestra app features. All participants receive a verbal review of the Orchestra features (during the consent process) and a paper-based quick start guide (included in Multimedia Appendix 3). In-depth tutorials are provided by RC coordinators if requested by a patient or family, or if the RC feels the patient needs additional instruction.

Intervisit Period

At the specified time and frequency, participants receive notifications to answer their selected trackers via their mobile

device. Participants' responses to trackers are displayed graphically, in real-time, on the app and on the Web-based platform. Line graphs display all data points chronologically with zoom in/out functionality. On the clinician-facing Web interface only, graphs include a median or mean line describing the central tendency of the data. Continuous measures also display control limits reflecting approximately 3 standard deviations from the mean, based on SPC rules. During the intervisit period, participants and clinicians are encouraged to record observations or questions by annotating data points, or via journal entries.

Clinicians are notified of significant changes in symptoms by email if SPC and/or threshold signals are set and the symptom data meet specified firing criteria. At any time during the intervisit period, if a participant shows a pattern of nonresponse (eg, is not completing daily trackers for 3 days in a row or weekly trackers for 2 weeks in a row), an RC contacts the participant to determine if the participant is experiencing technical problems or any other barriers to Orchestra use. As established in the social contract during the initial participant setup, check-ins are completed by the participant and clinician at the predetermined frequency. Check-ins are completed via MyChart (a patient communication portal available via the Epic EHR), email, phone, in-person, or using the journaling feature of the Orchestra app.

The PVP is automatically pushed to a participant's account approximately two weeks prior to a scheduled clinic visit. Participants are notified via their mobile device to review and complete the PVP. Clinicians are notified via email when a PVP is completed, and completed PVPs can be accessed at any time via the Orchestra platform.

Follow-Up Visits

Study follow-ups occur during routine clinic visits at 3 months (if applicable) and 6 months after enrollment. All participants are expected to have at least one follow up visit within 6 months of enrollment, based on standard clinical follow-up recommendations for IBD and CF. During the follow-up visit, clinicians and participants are encouraged to collaboratively review the PVP, symptom trackers, and journal entries and notes. Participants and clinicians are also encouraged to identify any changes in Orchestra setup (ie, tracker frequency, addition of a new tracker, discontinuation of a current tracker) that are needed to better learn from the data. After the clinical encounter, the RC meets with the participant to complete follow-up surveys and a structured qualitative interview.

Ongoing Process Improvements for Integrating Orchestra in the Clinic

Weekly standing meetings involving the research team and clinician champions from the CF and IBD clinics are held to discuss approaches to improve clinical processes, including: (1) how the patient/caregiver is introduced to Orchestra; (2) how clinicians are supported in using shared decision-making principles when discussing Orchestra during the clinical encounter; (3) patient technology setup (ie, Orchestra app install); and (4) workflows for managing the intervisit period. We use quality improvement methods to improve processes.

Technology Support

RCs are the first-line responders to technology issues reported by participants and clinicians. RCs attempt to solve barriers to using the technology and, if unsuccessful, report the technology issue to Vital Labs, Inc., which attempts to resolve the issue within 48 hours. RCs track the number and type of technology issues (*bugs*) to inform future improvements of the technology and develop more scalable processes for technology support.

Data Collection

Data Sources

Data are collected from participants via several sources, including: *Participant Assessments (Survey/Interview)*, *Clinician Assessments (Survey)*, *Orchestra Data*, and *Electronic Health Record/Clinical Outcome Data*.

Participant Assessments (Survey/Interview)

Enrolled participants complete surveys either at a scheduled clinic visit or via mail/email immediately following a clinic visit. Participants complete up to three assessments: baseline, 3-month (if applicable), and 6-month follow-up visits. Surveys are completed electronically via iPads or laptops directly linked to a Research Electronic Data Capture (REDCap) database for instant and secure electronic data storage. In-person interviews are conducted by the RC at the follow-up visits using a structured interview guide. Questions are designed to assess participants' experience with the tools, including how they used Orchestra, barriers and facilitators of use, ways in which Orchestra improves the patient's health status and experience with care delivery, and how the tool and intervention could be improved. RCs audio-record interviews and take written notes immediately following the interviews.

Clinician Assessments (Survey)

At each study visit, the patient's physician and, if applicable, a second clinical team member involved in using Orchestra with the patient complete surveys. Clinician surveys are emailed to each clinician via the REDCap survey administration feature.

Orchestra Data

Using the Orchestra mobile app and Web-based platform, participants input data, including but not limited to, self-report of symptoms and behaviors and validated PRO measures. Participants and clinicians can also enter journal comments and notes using the Orchestra platform. All data entered into the Orchestra platform are available to export in standard file formats.

Electronic Health Record/Clinical Outcome Data

Basic demographic information and data on patient outcomes are collected from the patient medical record and entered into the REDCap database. In addition, for the subset of patients who have a data alert signal during the study period, RCs review the EHR to determine if the data alert signal leads to action or a change in treatment plan. If unable to determine whether action occurred or if the action is related to the signal, the RC contacts the clinician to verify.

Measures

Demographic data are collected from all participants 18 years or older and caregivers provide data for patients under 18. We record the participants' age, race, ethnicity, gender, education, socioeconomic status, and familiarity with (and usage of) various technology platforms (eg, blogging, texting, using a tablet, video chatting). We also collect data on the patients' age at diagnosis and any comorbid medical conditions from the EHR.

We are evaluating fidelity to the Orchestra intervention by determining the extent to which the key components of the intervention are used, including selection of goal and measures, completion of PVP, in-clinic discussion of tracked data/PVP, and follow-up of signals generated by the Orchestra system. We are also examining how participants choose to configure Orchestra to meet individual patient and clinician goals by measuring: (1) who has elected to track (adolescent patients vs caregivers vs both), (2) how many symptoms they have chosen to track, (3) the most common symptoms tracked, and (4) use of the surveillance versus planned experimentation features. The main quantitative outcome measures (Table 1) are designed to assess *Feasibility*, *Acceptability*, and *Clinical Impact.*

Table 1. Quantitative outcome measures.

Measure		Baseline	3-month Visit	6-month Visit	Study Duration
Feasibility					
	Set up time for app[a]	X			
	Added burden to clinical visit (subjective)	X			
Acceptability					
	Enrollment rate[b]	X			
	Drop-out rate[b]				X
	Duration of engagement[b]				X
	Orchestra use (eg, chart views, use of notes, journals)				X
	Tracker completion rate				X
	Completion rate of PVP survey		X	X	
Clinical Impact					
	Perceived value		X	X	
	Improved treatment plan		X	X	
	Improved communication		X	X	
	Positive impact on care		X	X	
	Improved clinic preparation		X	X	
	Utility of the tools		X	X	
	Improved disease insight		X	X	
	Percent of signals resulting in change in care plan[c]				X
	Disease self-efficacy (change from baseline)	X	X	X	
	Participant engagement (change from baseline)	X	X	X	
	Number of hospitalizations				X
	Number of emergency department visits				X
	Weight, BMI, BMI percentile *(CF)*	X	X	X	
	FEV1 *(CF)*	X	X	X	
	Number of pulmonary exacerbations *(CF)*				X
	Number of intravenous antibiotic courses *(CF)*				X
	Days in remission *(IBD)*				X
	Days in sustained remission *(IBD)*				X

[a]Includes app download/installation, account and tracker configuration, delivery of the quick start guide, and verbal instruction for select patients.

[b]Measure of both feasibility and acceptability.

[c]Based on review of the EHR and/or discussion with clinician.

Feasibility

We are evaluating the feasibility of the Orchestra intervention and technology platform in a clinical environment. We are assessing the costs and benefits of adding Orchestra into the clinical workflow, including added time during the encounter and impact on visit and intervisit care management.

Acceptability

The acceptability of the Orchestra intervention and technology is being determined by examining the participants' tracker completion rate and the completion rate of the PVP. Other measures of acceptability include dropout rate (including participants who withdraw or those that are lost-to-follow-up) and sustained use over time.

Clinical Impact

We are evaluating the preliminary impact of the Orchestra intervention on outcomes, as reported by patients/caregivers and clinicians. We are assessing the perceived utility of Orchestra and impressions of the impact of Orchestra on care, collaboration, preparation and involvement in the clinic visit, disease insight, and treatment plan quality. We are also assessing changes in participant engagement in the visit and disease self-efficacy [21] from baseline to follow-up visits. Impact on the treatment plan is being measured objectively by examining whether data signals lead to action or change in treatment plan. We are also examining impact on clinical outcomes and health care utilization, although we anticipate that changes in these outcomes may not be realized in a short 6-month intervention.

Self-efficacy is being measured with the validated Self Efficacy for Managing Chronic Disease Questionnaire [21]. Engagement in the clinic and impact of using the Orchestra tool on care quality, patient-clinician collaboration, visit preparation, disease insight, treatment plan, and the tool's perceived usefulness are being assessed using a novel survey developed specifically for this study. Survey questions are answered using a 6-point scale ranging from *Strongly Disagree* (1) to *Strongly Agree* (6).

Sample Size Calculation

The goal sample size of 100 was determined based on knowledge of the eligible population in each clinic, frequency of clinic visits, available research resources, and a desire to complete the study within the span of one year while the technology remains current. As efficacy is not the primary endpoint, we did not perform an *a priori* power calculation.

Statistical Analyses

Quantitative Data

Version 24 of the IBM SPSS Statistics program will be used to perform all data analyses. Participant characteristics will be summarized and described. Measures of fidelity, feasibility, acceptability, and proximal clinical impact of the Orchestra intervention and technology platform that are obtained only at follow up-visits (eg, after the start of the intervention) will be summarized with descriptive statistics, including means and ranges for continuous variables and percentages for categorical variables. Data will be described separately for 3-month and 6-month follow-up visits because some patients may have only a 3-month or 6-month follow up-visit. For measures that are being assessed at both baseline and follow-up (eg, measures of disease self-efficacy and visit engagement), we will use paired t-tests to compare outcomes at the beginning and end of participation. We will use *t*-tests and the Cohen *d* statistic to determine the impact of condition (CF vs IBD), person tracking (caregiver or child), and baseline health status. Univariate analyses of variances will be used to assess participants' tool usage across study clinicians and across baseline health status. Pearson Correlation Coefficients will be used to examine relationships between tool use and perceived impact on care. Data regarding changes in health outcomes will be hypothesis-generating, as we do not expect impact on disease outcomes in a 6-month time frame.

Qualitative Data

The research team will review and code notes and audio recordings from patient interviews in addition to the log of issues, problems, and suggestions maintained by the research team. We will identify themes that emerge from the data to develop a better understanding of the experience of engaging with the Orchestra technology platform and intervention, and a more complete view of the ways in which this complex intervention impacts the patient's health status and experience with care delivery. Qualitative data will be used to enrich the quantitative data collection by providing a deeper and better understanding of acceptability, feasibility, and impact.

Results

Participant recruitment for phase 2 pilot testing began in May 2015 and continued until May 2016. Follow-up data collection was completed in autumn 2016. Results are expected in 2017.

Discussion

The clinical encounter is the setting in which outpatient health care happens; however, we are far from maximizing its potential to improve patient understanding, clinician efficiency and effectiveness, patient-clinician collaboration, and health outcomes [3,4]. mHealth technology has the potential to support a care delivery system that enables patients and clinicians to work together to create more collaborative, continuous, proactive, data-driven, and effective care [3,6-8]. However, despite the growth in mHealth technology, we have yet to see transformation in the way care is delivered to individuals with chronic illnesses [22]. By its very nature, chronic care delivery is always shared work (eg, coproduced) between patient and clinician [5], yet the vast majority of mHealth technology is built to facilitate the work of either patients (ie, personal health record, health tracking) or clinicians (ie, communication among colleagues, access to drug information, continuing education), as opposed to enabling patients and clinicians to collaboratively work together to coproduce better health and health care [6,7].

This study is designed to test the feasibility, acceptability, and preliminary impact of an mHealth technology platform and intervention aimed at transforming the management of chronic diseases and facilitating coproduction between patients and clinicians. Orchestra is designed to make care more collaborative, continuous, and effective by enabling

symptom/wellness tracking with real-time data visualization and sharing between patients and clinicians, automated symptom surveillance with actionable alerts to signal potential changes in patient status, collaborative previsit planning that includes personalized lab results and health metric feedback for patients, and opportunities for planned experimentation. While Orchestra can enable low-friction data collection, sharing, and communication, it will have minimal impact on chronic disease management unless it integrates seamlessly into patients' lives and clinicians' workflows in a way that relieves burden and addresses unmet needs [23]. Therefore, we have designed this pilot study to field-test the logistical aspects of Orchestra implementation in a real-life clinical setting in preparation for a larger, more definitive study to test the effectiveness of this type of technology-enabled coproduction in improving patient outcomes and health care value [9]. Our approach is focused not only on testing the feasibility and acceptability of the Orchestra technology, but also on refining the processes to optimize how Orchestra integrates into patients' and families' lives and clinicians' workflows, and to support patients and clinicians in using this technology to collaboratively produce better health care outcomes.

This study has several limitations. While broad inclusion criteria encourage a wide range of participants, we are recruiting from patients seen in two clinics at a single hospital. This convenience sample may not be representative of other clinics or the larger populations of children with IBD and CF. In addition, while measures of acceptability and feasibility can be obtained by directly measuring interaction with the app, our core measures of impact are being obtained from surveys of patients/caregivers and clinicians following clinical encounters. We have maximized research processes to optimize survey completion rates. However, our results have the potential to be negatively impacted by low response rates. Due to the pilot nature of this study and the desire to obtain feedback across a narrow range of acceptability [24] and feasibility dimensions, we are not explicitly using the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Future larger-scale studies and any planned implementation efforts of the Orchestra technology should examine the UTAUT model. Furthermore, there are multiple facets of feasibility and acceptability that are not being measured due to resource constraints and concerns about participant burden. For example, while we are tracking the frequency of technology bugs, we are not including robust measures of time and resources spent on technology support (eg, how much support was needed to address connectivity issues or data loss). Finally, this study is not designed to assess impact on clinical outcomes. Given the short duration of participant involvement (6-months), we do not anticipate seeing changes in longer-term health outcomes. Despite this limitation, if we observe improvements in short-term outcomes as measured in this study, we would feel more confident proceeding with a larger study designed to measure impact on clinical outcomes and health care value.

This study is novel in testing a technology coupled with processes that facilitate patient and clinician collaboration. This approach has the potential to shift the way mHealth technology is developed to support a model whereby equal attention is paid to the technology and the humans (patients, caregivers, and clinicians) who are the true agents of transformation.

Acknowledgments

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Conflicts of Interest

Orchestra was developed via a joint effort between Vital Labs, Inc. (Chief Executive Officer Ian Eslick, PhD) and CCHMC. Dr. Eslick, Dr. Opipari-Arrigan, Dr. Margolis, and Dr. Kaplan are coinventors of Orchestra and could be entitled to proceeds from the successful commercialization of the technology in the future. These individuals were involved in the preparation of the manuscript and study design as members of the research team. The other individuals involved in this proposed research have not reported any other interests or activities related to the Vital Labs or the Orchestra platform.

Multimedia Appendix 1

Orchestra screen shots.

[PDF File (Adobe PDF File), 303KB - resprot_v6i4e71_app1.pdf]

Multimedia Appendix 2

Examples of participant trackers.

[PDF File (Adobe PDF File), 207KB - resprot_v6i4e71_app2.pdf]

Multimedia Appendix 3

Orchestra participant quick start guide.

[PDF File (Adobe PDF File), 361KB - resprot_v6i4e71_app3.pdf]

References

1. Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511-544. [Medline: 8941260]
2. Boland P. The emerging role of cell phone technology in ambulatory care. J Ambul Care Manage 2007;30(2):126-133. [doi: 10.1097/01.JAC.0000264602.19629.84] [Medline: 17495681]
3. Spiegel B. 2015 American Journal of Gastroenterology lecture: how digital health will transform gastroenterology. Am J Gastroenterol 2016 May;111(5):624-630. [doi: 10.1038/ajg.2016.68] [Medline: 27045930]
4. Olsen L, Aisner D, McGinnis LM, editors. Institute of Medicine. The learning healthcare system: workshop summary. Washington, DC: The National Academies Press; 2007.
5. Batalden M, Batalden P, Margolis P, Seid M, Armstrong G, Opipari-Arrigan L, et al. Coproduction of healthcare service. BMJ Qual Saf 2016 Jul;25(7):509-517 [FREE Full text] [doi: 10.1136/bmjqs-2015-004315] [Medline: 26376674]
6. Biesdorf S, Niedermann F. Healthcare's digital future. URL: http://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/healthcares-digital-future [accessed 2016-11-22] [WebCite Cache ID 6mDRgkaf5]
7. IMS Institute. 2015. Patient Adoption of mHealth URL: http://www.imshealth.com/en/thought-leadership/quintilesims-institute/reports/patient-adoption-of-mhealth [accessed 2016-11-22] [WebCite Cache ID 6mDRO7iH4]
8. Topol E. The creative destruction of medicine: how the digital revolution will create better health care. New York: Basic Books; 2012.
9. Fiks AG, Mayne SL, Karavite DJ, Suh A, O'Hara R, Localio AR, et al. Parent-reported outcomes of a shared decision-making portal in asthma: a practice-based RCT. Pediatrics 2015 Apr;135(4):e965-e973. [doi: 10.1542/peds.2014-3167] [Medline: 25755233]
10. Arnhold M, Quade M, Kirch W. Mobile applications for diabetics: a systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older. J Med Internet Res 2014;16(4):e104 [FREE Full text] [doi: 10.2196/jmir.2968] [Medline: 24718852]
11. Cafazzo JA, Casselman M, Hamming N, Katzman DK, Palmert MR. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. J Med Internet Res 2012;14(3):e70 [FREE Full text] [doi: 10.2196/jmir.2058] [Medline: 22564332]
12. Modave F, Bian J, Rosenberg E, Mendoza T, Liang Z, Bhosale R, et al. DiaFit: the development of a smart app for patients with type 2 diabetes and obesity. JMIR Diabetes 2016 Dec 13;1(2):e5. [doi: 10.2196/diabetes.6662]
13. Kang H, Park H. A mobile app for hypertension management based on clinical practice guidelines: development and deployment. JMIR Mhealth Uhealth 2016 Feb 02;4(1):e12 [FREE Full text] [doi: 10.2196/mhealth.4966] [Medline: 26839283]
14. Jamison RN, Ross EL. Utilization, reliability, and validity of a smartphone app for chronic pain management: a randomized trial. iproc 2016 Dec 23;2(1):e20. [doi: 10.2196/iproc.6060]
15. Hamine S, Gerth-Guyette E, Faulx D, Green BB, Ginsburg AS. Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. J Med Internet Res 2015;17(2):e52 [FREE Full text] [doi: 10.2196/jmir.3951] [Medline: 25803266]
16. Fore D, Goldenhar LM, Margolis PA, Seid M. Using goal-directed design to create a novel system for improving chronic illness care. JMIR Res Protoc 2013 Oct 29;2(2):e43 [FREE Full text] [doi: 10.2196/resprot.2749] [Medline: 24168835]
17. Kaplan HC, Adler J, Saeed SA, Eslick I, Margolis PA. Harvard Business Review. 2013. A personalized learning system for improving patient-physician collaboration URL: https://hbr.org/2013/10/a-personalized-learning-system-for-improving-patient-physician-collaboration [accessed 2017-01-25] [WebCite Cache ID 6pqxeFrpd]
18. The E3 Healthcare Study. 2014. URL: http://c3nproject.org/sites/bmidrupal7pc3n.chmcres.cchmc.org/files/innovation-handouts/E3HEALTHCARE_C3N%20Innovation%20Handout_20140123.pdf [accessed 2017-01-25] [WebCite Cache ID 6nmciPxL0]
19. Kistin C, Silverstein M. Pilot studies: a critical but potentially misused component of interventional research. JAMA 2015 Oct 20;314(15):1561-1562 [FREE Full text] [doi: 10.1001/jama.2015.10962] [Medline: 26501530]
20. Benneyan JC, Lloyd RC, Plsek PE. Statistical process control as a tool for research and healthcare improvement. Qual Saf Health Care 2003 Dec;12(6):458-464 [FREE Full text] [Medline: 14645763]
21. Lorig KR, Sobel DS, Ritter PL, Laurent D, Hobbs M. Effect of a self-management program on patients with chronic disease. Eff Clin Pract 2001;4(6):256-262 [FREE Full text] [Medline: 11769298]
22. Grossmann C, Goolsby WA, Olsen A, McGinnis LM, editors. Institute of Medicine. Engineering a Learning Healthcare System: A Look at the Future: Workshop Summary. Washington, DC: The National Academies Press; 2011.

23. Miyamoto SW, Henderson S, Young HM, Pande A, Han JJ. Tracking health data is not enough: a qualitative exploration of the role of healthcare partnerships and mHealth technology to promote physical activity and to sustain behavior change. JMIR Mhealth Uhealth 2016 Jan 20;4(1):e5 [FREE Full text] [doi: 10.2196/mhealth.4814] [Medline: 26792225]
24. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: toward a unified view. MIS Quarterly 2003 Sep;27(3):425-478.

Abbreviations

BMI: body mass index
CCHMC: Cincinnati Children's Hospital Medical Center
CF: cystic fibrosis
EHR: electronic health record
FEV1: Forced Expiratory Volume in 1 second
IBD: inflammatory bowel disease
ID: identification
IRB: Institutional Review Board
mHealth: mobile health
PHI: protected health information
PRO: patient-reported outcome
PVP: previsit plan
RC: research coordinator
REDCap: Research Electronic Data Capture
SMS: short messaging system
SPC: statistical process control
UTAUT: Unified Theory of Acceptance and Use of Technology
VPC: virtual private cloud

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Protocol

Mobile Application to Promote Adherence to Oral Chemotherapy and Symptom Management: A Protocol for Design and Development

Joel Nathan Fishbein[1*], BA; Lauren Ellen Nisotel[2*], BS; James John MacDonald[3], BA; Nicole Amoyal Pensak[4], PhD; Jamie Michele Jacobs[5,6], PhD; Clare Flanagan[7,8], BA; Kamal Jethwani[7,9], MPH, MD; Joseph Andrew Greer[5,6], PhD

[1]Department of Psychology and Neuroscience, University of Colorado Boulder, Boulder, CO, United States
[2]Department of Epidemiology, Harvard TH Chan School of Public Health, Boston, MA, United States
[3]Department of Psychology, University of California, Los Angeles, Los Angeles, CA, United States
[4]Anschutz Medical Campus, Department of Medicine, University of Colorado Denver, Denver, CO, United States
[5]Center for Psychiatric Oncology and Behavioral Sciences, Massachusetts General Hospital and Harvard Medical School, Boston, MA, United States
[6]Department of Psychiatry, Massachusetts General Hospital and Harvard Medical School, Boston, MA, United States
[7]Partners Connected Health, Partners HealthCare, Boston, MA, United States
[8]Department of Global Health and Population, Harvard TH Chan School of Public Health, Boston, MA, United States
[9]Department of Dermatology, Massachusetts General Hospital and Harvard Medical School, Boston, MA, United States
[*]these authors contributed equally

Corresponding Author:
Joseph Andrew Greer, PhD
Center for Psychiatric Oncology and Behavioral Sciences
Massachusetts General Hospital and Harvard Medical School
55 Fruit St
Boston, MA,
United States
Phone: 1 617 643 2143
Fax: 1 617 643 9913
Email: jgreer2@mgh.harvard.edu

Abstract

Background: Oral chemotherapy is increasingly used in place of traditional intravenous chemotherapy to treat patients with cancer. While oral chemotherapy includes benefits such as ease of administration, convenience, and minimization of invasive infusions, patients receive less oversight, support, and symptom monitoring from clinicians. Additionally, adherence is a well-documented challenge for patients with cancer prescribed oral chemotherapy regimens. With the ever-growing presence of smartphones and potential for efficacious behavioral intervention technology, we created a mobile health intervention for medication and symptom management.

Objective: The objective of this study was to develop and evaluate the usability and acceptability of a smartphone app to support adherence to oral chemotherapy and symptom management in patients with cancer.

Methods: We used a 5-step development model to create a comprehensive mobile app with theoretically informed content. The research and technical development team worked together to develop and iteratively test the app. In addition to the research team, key stakeholders including patients and family members, oncology clinicians, health care representatives, and practice administrators contributed to the content refinement of the intervention. Patient and family members also participated in alpha and beta testing of the final prototype to assess usability and acceptability before we began the randomized controlled trial.

Results: We incorporated app components based on the stakeholder feedback we received in focus groups and alpha and beta testing. App components included medication reminders, self-reporting of medication adherence and symptoms, an education library including nutritional information, Fitbit integration, social networking resources, and individually tailored symptom management feedback. We are conducting a randomized controlled trial to determine the effectiveness of the app in improving adherence to oral chemotherapy, quality of life, and burden of symptoms and side effects. At every stage in this trial, we are engaging stakeholders to solicit feedback on our progress and next steps.

Conclusions: To our knowledge, we are the first to describe the development of an app designed for people taking oral chemotherapy. The app addresses many concerns with oral chemotherapy, such as medication adherence and symptom management. Soliciting feedback from stakeholders with broad perspectives and expertise ensured that the app was acceptable and potentially beneficial for patients, caregivers, and clinicians. In our development process, we instantiated 7 of the 8 best practices proposed in a recent review of mobile health app development. Our process demonstrated the importance of effective communication between research groups and technical teams, as well as meticulous planning of technical specifications before development begins. Future efforts should consider incorporating other proven strategies in software, such as gamification, to bolster the impact of mobile health apps. Forthcoming results from our randomized controlled trial will provide key data on the effectiveness of this app in improving medication adherence and symptom management.

Trial Registration: ClinicalTrials.gov NCT02157519; https://clinicaltrials.gov/ct2/show/NCT02157519 (Archived by WebCite at http://www.webcitation.org/6prj3xfKA)

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KEYWORDS

telemedicine; neoplasms; mobile apps; medication adherence; self-administration; antineoplastic agents; ambulatory monitoring; mHealth; software design

Introduction

Background

Oral chemotherapies are increasingly prescribed as an alternative therapeutic delivery method to traditional intravenous chemotherapy. In 2008, an estimated 25% of the more than 400 chemotherapeutics being developed involved oral agents [1]. Oral chemotherapy provides many benefits, including ease of administration, convenience, and minimization of invasive infusions. In addition, research has shown that patients receiving cancer treatment prefer oral chemotherapy versus intravenous, given equal efficacy and toxicity [2,3]. Thus, oral chemotherapy medications offer flexible, home-based treatment that has been associated with improvements in quality of life by reducing interference with daily activities, heightening perceived control over treatment, and increasing convenience [2,4,5].

Despite this revolutionary shift in cancer care delivery, home administration presents unique challenges to patients and clinicians. Home administration results in less oversight, support, and symptom monitoring from clinicians as compared to directly observed infusion chemotherapy [6]. In turn, patients may waver with regard to their medication adherence, and treatment might not be as effective as intended. It is well documented that patients with cancer have suboptimal adherence to oral chemotherapy [7-9]. Researchers have observed wide variations in adherence to oral chemotherapy depending on method of assessment, reporting rates as low as 16% [8]. The importance of oral chemotherapy adherence cannot be overstated, as patients who have poor adherence are more likely to experience worse clinical outcomes, such as morbidity, recurrence, and mortality . Suboptimal adherence to oral chemotherapy results in poor quality care, presenting a significant public health concern. As oral chemotherapy plays a more prominent role in cancer treatment, it is important to address medication adherence and improve symptom management for patients [10].

Limited research has been conducted to examine intervention methods to improve adherence to oral chemotherapy. The few intervention studies conducted to date have proven inconclusive in their effectiveness in improving adherence and display methodological limitations such as nonrandomized design and small sample sizes [11]. Thus, further research is greatly needed to develop and test novel, theoretically grounded, accessible interventions to promote patient medication adherence behaviors and symptom management.

Intervention accessibility is enhanced with the use of mobile health (mHealth) technology for the delivery of health care and wellness support [12]. Specifically, mobile phones allow behavioral science researchers to implement ecological momentary interventions and ecological momentary assessments (EMIs, EMAs) to deliver interventions and gather data in real time, under convenient and accessible real world situations [13]. Smartphones present an opportunity to implement more sophisticated EMIs and gather more detailed EMAs than prior research that has used short message service technology through pagers or non-Internet enabled cellular devices [14,15]. Researchers are thus able to optimize the delivery of behavioral interventions and collect ongoing data with minimal burden to the patient and provider. A recent review indicates that leveraging mobile technologies to deliver accessible interventions can improve health behaviors in patients with cancer [16]. Additionally, there is a proliferation of efforts in the literature to develop smartphone mobile app-based medication adherence interventions across varying chronic illnesses [17-22]. Smartphone mobile apps provide an ideal platform to provide relevant patient support in a context of medication adherence. Thus, we developed a mobile app intervention, *C* hem *o* the *r* apy *A* ssistant (CORA), to improve medication adherence and symptom management for patients with cancer taking oral chemotherapies.

The aim of this paper is to describe the theoretically based development of a smartphone mobile app intervention for oral chemotherapy adherence and symptom self-management in a diverse cancer population. Experts in behavioral intervention technology and mHealth implementation science have called for contributions to the literature that detail the development process of mHealth interventions [23]. Approximately 30,000 to 90,000 health care–related apps are currently available to consumers, while the US Food and Drug Administration has

reviewed approximately 100 [12]. In an effort to increase transparency in mHealth intervention development, we describe the theoretical framework that supports the use of modern mobile technology to address oral chemotherapy adherence and symptom management and we detail the iterative process that our research and development teams undertook to design and create the CORA mobile app. Specifically, we used a framework for mHealth intervention development detailed by Whittaker et al [24] to guide the creation of our mobile app intervention. Steps identified as leading to successful intervention development include theoretical conceptualization, formative research, pretesting, piloting, randomized controlled trial, and qualitative follow-up. The remainder of this paper details our conceptual model, design stages, and stakeholder engagement in qualitative formative research, as well as development, refinement, finalization, and piloting of our smartphone app for improving symptom management and adherence to oral chemotherapy. We conclude with a discussion of lessons learned throughout the process.

Methods

Setting

This mixed-methods, randomized, parallel assignment, intervention trial [ClinicalTrials.gov: NCT02157519] began in 2014 and is currently being conducted at the Massachusetts General Hospital (MGH) Cancer Center, an academic hospital comprised of 24 multidisciplinary disease centers. The study was approved by the Dana Farber/Harvard Cancer Center Institutional Review Board (IRB) and is supported by the Patient-Centered Outcomes Research Institute (IHS-1306-03616).

Procedure

Phase I (the study being described here) consisted of the mobile app development process and initial results of acceptability that were completed in 5 steps. Phase II, currently underway, consists of a randomized controlled trial (RCT) to test acceptability, feasibility, and efficacy of the mobile app intervention in improving adherence to oral chemotherapy and symptom management in patients with cancer.

The 5-step development process in phase I consisted of identifying desired features, content, and functionality of a mobile app in an iterative process. Step 1 included using expert collaboration and theoretical framework to guide initial content development. In step 2, we conducted focus groups with key stakeholder groups to inform the study design and development of the mobile app. Step 3 involved the creation of wireframes for the initial app components (eg, adherence, symptom management, communication with treatment team, educational resources) and individual interviews with patients and clinicians to review the proposed app content using these screen blueprints. Step 4 consisted of designing, programming, and further refining the prototype of the app for testing. Last, step 5 entailed the finalization of the prototype for the RCT.

Research, Development, and Stakeholder Teams

The multidisciplinary research team consisted of the principal investigator, co-investigators (expert clinicians and scientists specializing in psychology, oncology, and psychiatry), a project director, and 3 research assistants. The technical development team was comprised of programmers and project managers at Partners HealthCare Connected Health. Stakeholders served as expert consultants, including oncology clinicians, health care representatives, practice administrators, patients, and family members. All stakeholder groups reviewed the proposed study design and app features, providing initial feedback on acceptability of content and implementation of the intervention. Patients and family caregiver stakeholders also participated in alpha and beta testing, including qualitative interviews to assess the acceptability and ease of using the intervention.

Step 1: Implementing a Theoretical Framework

As oncology clinicians are increasingly prescribing oral chemotherapy in cancer care settings, new concerns are emerging with respect to patients self-administering medications with high toxicity profiles. Patients and their family caregivers now bear the primary responsibility of administering care, often with less frequent follow-up and support from their health care team to ensure proper adherence and to monitor and manage symptoms. To address these salient issues and guide the development of CORA, our research and development team consulted the conceptual model by Murray et al [25] which identifies key elements of medication adherence. Factors contributing to medication adherence in chronic illness are best understood across patient, provider, and health care system levels. The model describes the interaction among these patient, provider, and health care system factors and their influence on the relationship between increased medication adherence and improved health outcomes. Four factors were identified as the most important barriers to oral chemotherapy adherence: complexity of medication regimens, symptom burden, poor self-management of side effects, and low clinician support. A description of how the present mobile app intervention was designed to intervene on these barriers to medication adherence and symptom management is provided in Table 1 and is the basis for the development of app content. By increasing patient engagement with treatment, providing simple medication reminders, assisting patients with symptom monitoring and management, and facilitating communication with the care team in the form of a low-burden, easily accessible, and user-friendly mobile smartphone app, barriers to optimal adherence to medication may be overcome.

Table 1. Assessing and intervening on the barriers to optimal medication adherence.

Barrier	How addressed in Chemotherapy Assistant (CORA)
Complex medication regimens	Personalized medication treatment plan: medication, dosage, frequency of drug, breaks/chemo holiday, medication reminder alerts.
Symptom burden	Symptom reporting: patients can report symptoms as they are occurring, receive tailored feedback, and send the symptom report to their care team.
Poor self-management of side effects	Symptom feedback: CORA asks questions to assess the severity and frequency of symptoms and provides feedback for managing symptoms and resources for contacting care team.
Low clinician support	Weekly symptom reports: symptom reports are sent to each patient's care team on a weekly basis to inform clinical decision making.

Step 2: Conducting Initial Focus Group Interviews With Key Stakeholders

Stakeholder Selection

To inform the study and development of the intervention, we sought out stakeholders both within and outside the local community, obtaining comprehensive feedback across levels of expertise in cancer. Drawing from a model of population-based patient-centered care, 32 stakeholders served as study collaborators and comprised 4 key stakeholder groups: (1) patient/families (n=8); (2) oncology clinicians (n=8); (3) cancer practice administrators (n=8); and (4) representatives of the health system, community, and society (n=8). We pulled from a diverse group of professionals, including pharmacists, health care leaders, lawyers, and patient advocates to inform decisions related to pharmacology, liability, health communication, and support resources. The patient and family member stakeholder group took place in person onsite at the MGH Cancer Center. For the other stakeholder groups, the interviews took place via teleconference call, as many of the participants were from organizations and care settings across the United States. Stakeholders were included as consultants in the study and were not consented as participants; therefore, we did not collect demographic or other personal information from the stakeholders.

The goal of these initial focus group interviews was to obtain feedback about the proposed study topic, design, and intervention. The stakeholder interview guide included the following topics: (1) perceived importance of monitoring of adherence to oral chemotherapy; (2) barriers to communication between patients and oncology team regarding management of side effects and medication adherence; (3) potential role of the mobile app to address barriers to quality of cancer care; (4) potential feasibility, acceptability, and usability of an mHealth intervention; (5) feedback on the overall study design; and (6) systems barriers and facilitators to implementation. Stakeholder conversations were heavily focused on logistics of implementation in the clinic.

Patient and Family Member Stakeholder Group

A total of 8 patient and family caregiver stakeholders participated in a focus group to provide feedback about their experiences relevant to the patient taking oral chemotherapy in order to promote user acceptability. Although the app is intended for use only by patients, we believed that family caregivers could provide additional insights as they are often highly involved in patient medication and symptom management. Key points from these focus groups included developing features that would optimize potential benefit and minimize burden. Both patients and family members strongly recommended a symptom monitoring feature with easily interpretable graphics to display symptom severity over time. In addition, patients and family members emphasized the importance of clear instructions within the app regarding how to address and follow-up on urgent versus nonurgent symptoms. This feedback was integral toward informing the development of the app and establishing a protocol to alert patients when they should immediately contact their care team after reporting a concerning symptom.

Oncology Clinician, Practice Administrator, and Health Care Representative Stakeholders

We conducted 3 separate focus group interviews via teleconference call for the oncology clinician, practice administrator, and health care representative stakeholders. These focus groups identified themes related to intervention content, randomized trial study design, and methods for implementation. Health care representatives suggested providing patients with relevant clinical resources in the app such as disease-specific social networking sites, as well as the importance of promoting patient-physician communication through symptom reporting. Practice administrators provided suggestions for capturing important outcomes and data management, from stratifying randomization in the RCT by line of chemotherapy to tracking participant usage of CORA. Oncology clinicians provided feedback on involving the care team without burden, as well as promoting participant engagement through incentivizing features such as a Fitbit device with activity tracking enabled in the mobile CORA app.

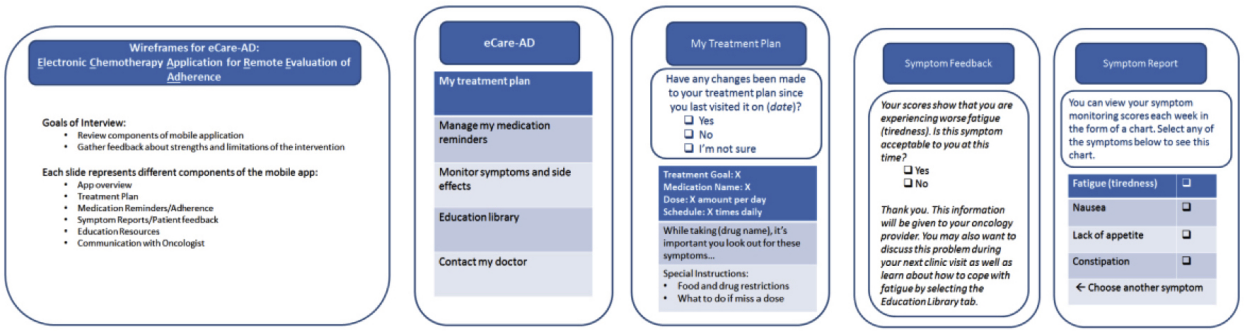
Step 3: Creating Wireframes and Collecting Specific Feedback on App Components

Creation of Wireframes and Interview Guide

In addition to conducting initial stakeholder focus groups, the research and design teams created content wireframes (ie, screen blueprints) to provide a visual guide for the components of CORA (see Figure 1). We created wireframes for the following mobile app sections: personalized treatment plan, medication reminder system, symptom reporting, education library, and notes and questions. The research team then used these wireframes to conduct individual qualitative interviews with 10 patients and 8 oncology clinicians at the MGH Cancer Center.

The semistructured interview guides for patients and clinicians addressed 3 domains: (1) components of the mobile app, (2) feasibility and usability of the mobile app, and (3) weekly in-app symptom assessments to be shared with the prescribing oncology clinician. Patients were asked to consider which features they would be likely to use in a mobile app to support medication taking. Clinicians were asked to provide input on the timing, frequency, and feasibility of receiving symptom assessment reports weekly, as well as potential barriers or burdens of this feature. All patient and clinician participants signed IRB-approved consent forms, and the interviews were audiorecorded.

Figure 1. Wireframes for Chemotherapy Assistant mobile app.



Collecting Feedback From Massachusetts General Hospital Patient Participants

A total of 10 patients at the MGH Cancer Center participated in qualitative interviews to evaluate the acceptability as well as potential feasibility and usability of a mobile app intervention to help improve adherence to oral chemotherapy and symptom management. The majority of the patients were female (6 female, 4 male), white (8 white, 1 Asian, 1 Hispanic/Latino), married (7 married, 3 single), and well-educated (6 completed college or higher, 2 completed high school or GED) with a mean age of 58.40 (SD 8.02) years. All the patients had been prescribed oral chemotherapy for the treatment of either non–small cell lung cancer (n=4), breast cancer (n=2), prostate cancer (n=1), chronic myeloid leukemia (n=1), or multiple myeloma (n=1).

Goals of the individual interviews were to gauge patient interest in a mobile app intervention and gather feedback about suggested topics to include within the education section, aesthetics, and frequency of push notifications to patients. The patient participants also provided feedback on current problems and difficulties as well as their preferences for using CORA.

Collecting Feedback From Massachusetts General Hospital Oncology Clinicians

A total of 8 oncology clinicians (6 female, 2 male), including 4 physicians and 4 nurse practitioners who specialize in breast oncology (n=2), genitourinary oncology (n=3), thoracic oncology (n=2), and melanoma (n=1) at the MGH Cancer Center, also viewed the wireframes and completed qualitative interviews to inform the implementation of the mobile app intervention. Themes from these qualitative interviews included the structure and frequency of weekly symptom reports sent from the mobile app server to the clinician, incorporation of the intervention into a patient's treatment plan, and mitigating risk involved with symptom reporting via CORA. These interviews were integral in establishing the practical methodology for successfully implementing this project locally, at the main site, before disseminating more widely at community affiliates.

Step 4: Developing, Programming, and Refining the App

Technical Specifications and Process

The CORA mobile app was originally developed on the Titanium 3.5 (Appcelerator Inc) platform to ensure cross-platform functionality on both Apple iOS and Android devices. Later updates were developed on Titanium 5.0. While CORA was written primarily in JavaScript language, some custom features (using native functionality) were written in Objective-C and Java, such as the local notifications.

CORA was developed to minimize app-driven data and battery use. For example, symptom data and survey responses were programmed to be transmitted to the server once weekly. Analytics data were programmed to be sent once daily. In both cases, in the event of no Internet connection, CORA transmits the data at the next connection opportunity. Medication reminders were programmed as local notifications to ensure delivery independent of Internet connection. All app-related data are encrypted both on the smartphone and during data transmission, independent of the user phone's level of encryption.

CORA is supported by a PHP/MySQL database, which is hosted on a LAMP (Linux, Apache, MySQL, Perl/PHP/Python) server that meets all Health Insurance Portability and Accountability Act (HIPAA) Security Rule requirements. The database collects and stores all user-inputted information and engagement metrics, tracking which pages each user visits and how long the user remains on a given page. User-inputted information is used to generate weekly symptom reports to providers and measure study outcomes.

CORA underwent code reviews and quality assurance testing with each code release. The entire study team, including developers, research staff, and clinicians, participated in the quality assurance process.

Alpha Testing

The development of CORA was conducted through an iterative process between the research and technical development teams. In addition to the focus group and qualitative interviews that were conducted before development, we gathered feedback from the patient and family stakeholders throughout the development process and following the release of the beta app.

Toward the conclusion of the development cycle, we invited members of the initial patient and family stakeholder group to participate in user acceptance testing (UAT). Participants with varying levels of comfort using technology were included in order to maximize generalizability. During UAT sessions, research and development staff observed users during their initial interactions with CORA. Participants were then asked to complete specific tasks within the demo app. For example, participants were asked, "How do you think you would go about adding your oral chemotherapy medication to this app?" Research and development staff then observed participants completing the different tasks. Participants were invited to share general feedback on CORA toward the end of the testing session, specifically on how intuitive they considered the tasks to be. We recorded participant responses, and this exercise helped the development team determine whether users would be able to navigate CORA intuitively on their own. Feedback from the UAT was then incorporated into the development cycle to improve the user experience within CORA. Prior to the finalization of the prototype, the research team (N=4) reviewed multiple iterations of CORA and provided aesthetic and functional feedback to the technical team on a weekly basis.

Step 5: Finalizing the App Prototype

Beta Testing

To obtain and incorporate more long-term user feedback, the research team considered the first 5 participants enrolled in the subsequent RCT phase who received the CORA app intervention as beta testers. After the first 5 participants completed the 12-week follow-up assessment, research staff conducted qualitative interviews with them to learn about their use of the CORA app. The 5 participants completed a 20-minute, semistructured interview about their experiences using CORA. Interview questions evaluated the feasibility, usability, and aesthetics, allowing users to suggest changes or enhancements.

Additionally, the research team conducted qualitative interviews with 5 oncology clinicians who had patients assigned to the intervention group. Upon completion of study procedures, these clinicians were interviewed about their conversations with patients pertaining to CORA, as well as interpretation and helpfulness of the weekly symptom reporting feature.

Results

Feedback from stakeholders and beta testers highlighted specific features that they believed needed to be addressed in the app. Patients, caregivers, health care representatives, and practice administrators provided suggestions related to the patient experience of the app; oncology clinicians also made suggestions that would best enable oncology care teams to make use of the data that patients enter into the app. Key feedback provided by each group and the implementation of that feedback in the app is shown in Table 2.

Table 2. Stakeholder and beta tester feedback and implementation of that feedback.

Group	Quotes from stakeholder feedback	Implementation
Patients and families	"Connect patients with the same disease type for social support."	Feature: Education Library Module—Resources and Social Networking. CORA includes a list of reputable, disease-specific resources for patients looking to connect with others.
Health care representatives	"Provide patients with anchors and definitions of symptoms so they can appropriately determine the severity and urgency of their symptoms."	Feature: Symptom Reporting Module. When a patient reports a symptom, CORA asks several questions about the frequency and duration before providing tailored feedback.
Oncology clinicians	"The weekly symptom reports that are sent to clinicians should be concise and easy to understand."	Feature: Symptom Reporting Trends Module. Weekly symptom reports provide a list of symptoms reported by the patient, as well as a color and numeric value (1-10) denoting severity.
Practice administrators	"Provide resources and contact information for patients to use when they miss a dose of their medication."	Feature: Symptom Reporting Module—"touch to call clinical team" feature. Patients are provided with the study team contact information at baseline. Embedded in the symptom reporting feature is a "touch to call" button for their specific clinic.

The version of CORA delivered at the end of the development process described here is organized into 6 functional modules (Table 3). Each module is accessed via a navigation bar at the bottom of the app's screen. In the Homepage module, a personalized medication treatment plan shows users their oral chemotherapy medication name and dosage and provides reminder alerts to take their oral chemotherapy at their self-selected daily dosage time. The Homepage also displays healthy recipe recommendations. The Symptom Reporting Module enables users to record concerning symptoms (eg, high fever) or more common symptoms (eg, fatigue) on a daily basis. Users can report severity of these symptoms on a continuous

sliding scale from mild to severe. When users report symptoms, the module probes them to provide specific information about each symptom with multiple choice questions, and based on user responses, provides personalized management recommendations for that symptom. Additionally, if participants report concerning symptoms in the app such as high fever, the app recommends that the participant immediately call their doctor and provides the oncology on-call clinic number onscreen. Weekly summaries of user reported symptoms and severity, converted to a 0 to 10 value based on where the participant placed the slider on the scale, are compiled into automated report documents. The study team then sends these reports via secure email to users' medical oncologists and oncology nurse practitioners. Trends in these symptoms are displayed on the CORA app in graphical format in the Symptom Reporting Trends module, showing users the severity of each symptom on each day it was reported. The Education Library module provides information about common symptoms and symptom management, nutrition, and links to online resources relevant for individuals with cancer, such as the Leukemia and Lymphoma Society's online community discussion forum. To help users remember what they want to discuss at their next clinic visit, the Notes and Questions module provides a free-response text field to record questions for their oncologist. The Wearable Fitness Tracking Device module syncs data from Fitbit devices and displays daily step counts. Finally, the app also enables users to set daily step goals and displays progress toward their goals.

Table 3. Organization of Chemotherapy Assistant (CORA) modules and their components.

Module	Components
Homepage	Medication treatment plan, suggested healthy recipes.
Symptom reporting	Weekly and real-time symptom reporting for common symptoms and treatment side effects, with algorithms that personalize symptom management suggestions or enable participants to call their care team directly from the app.
Symptom reporting trends	Graphical display of weekly symptom trends, customized for each patient and their medical oncologist.
Education library	Symptom management, social networking and support resources, nutrition, and clinic contact information.
Notes and questions	Store notes and questions for future clinic visits.
Wearable fitness tracking device	Stream data from Fitbit devices to CORA, display daily step counts, and allow users to set daily step goals and display progress towards those step goals.

CORA is compatible with iOS [iPhone] and Android smartphone operating systems and all Fitbit wearable fitness tracker devices. Due to limited engineering resources, we could not support compatibility with other operating systems and wearable device brands in this version of CORA.

As we are now testing CORA in an RCT (since the trial is in progress, results of the RCT are not reported here), we continue to refine the app. For example, as newer iOS, Android, and Fitbit software is released, we make changes to the app to ensure continuing compatibility. We likewise address any software bugs that emerge by communicating with the programming team to determine the cause of and the solution to the bug. Once the new CORA version is ready, the research team guides participants through upgrading to that version and provides that version to new participants. We have created 7 updated versions of the app during the RCT phase (since August 2014): 4 updates addressed integration with third-party smartphone operating systems and 3 updates addressed bugs or minor improvements (eg, adding additional question logic to the medication treatment plan in the Homepage module) deemed necessary by the study team.

We also continue to engage with our stakeholders throughout the RCT phase with quarterly updates on progress of the study. Twice, we have asked stakeholders to provide feedback on aspects of the RCT, including whether any additional incentives should be provided to study participants and how best to engage clinicians in the study. After the RCT is complete, we will solicit final feedback from our stakeholders about the preliminary analyses and interpretation of the results, methods for improving the app for future uses, and plans for broader dissemination across care settings.

Discussion

Principal Findings

We developed a novel smartphone app to improve oral chemotherapy adherence and self-management of symptoms for patients with cancer. The app development was informed by a conceptual model that attributed poor oral chemotherapy adherence to patient, clinician, and health care system factors. Based on this model, we designed a prototype version of the app. In focus groups and individual qualitative interviews, we solicited feedback from stakeholder groups, including patients, patients family members, oncology clinicians, oncology practice administrators, and representatives of health care organizations. We also conducted user testing on an early version of the app to assess acceptability and usability. The feedback elicited from our stakeholders and testers informed ongoing refinement of the prototype. Having completed initial development, we are iteratively updating and improving the app based on feedback from stakeholders and participants in an ongoing RCT.

CORA addresses many challenges that patients and providers face with oral chemotherapy. Although oral chemotherapies are increasingly being developed and used in standard care [1,26] and patients prefer these treatments to intravenous chemotherapy [2,27], treatment with oral chemotherapy poses barriers for adherence and monitoring of side effects [28]. We aimed to improve adherence with CORA by providing automated medication reminders, personalized dosing and treatment

information, and weekly questionnaires assessing adherence and symptoms. Patient responses on the weekly adherence questionnaires are sent to their care teams, which may help clinicians intervene when patients are struggling to take their medication as prescribed. Likewise, we aimed to address management of side effects with app features for reporting and tracking symptoms and side effects in real time. We included an ad hoc symptom questionnaire in the app for patients to log symptoms they are experiencing at any time. Simple graphs show users the trends in symptoms they have reported over time. As with the adherence questionnaires, we send symptom summaries to their respective clinicians so they can follow up with patients about new or chronic symptoms at their next scheduled visit or intervene sooner based on their clinical judgment.

We engaged stakeholders representing all types of individuals and organizations that could be influenced by the dissemination of our app. One stakeholder group was patients diagnosed with cancer, the intended future users of the technology. We also included family members as stakeholders, given that caregivers often administer medications and communicate with the care team. As our app aims to enhance how clinicians manage their patients taking oral chemotherapy, we included stakeholder groups of oncology clinicians and practice administrators. Finally, we included stakeholders representing health care institutions, including insurers, patient advocacy groups, research hospitals, and pharmaceutical companies. These organizations may influence future development, use, and dissemination of our app.

Feedback from experts in diverse fields ensured that our app is relevant for individuals and organizations involved in cancer care. For example, the clinician stakeholder group provided useful feedback about how to avoid overburdening clinicians with symptom reports from their patients. Their suggestions ultimately shaped the system that was implemented. We engaged stakeholders at every stage of development. Focus groups conducted before any development took place informed the modules of the app that were ultimately included. Reviewing wireframes and early app versions with patients and clinicians helped us address concerns with the look, feel, and use of the app before it was finalized. We are continuing to solicit feedback from stakeholder groups during the RCT phase to ensure that our app remains current with continuously changing trends in technology and health care. Additional focus groups conducted at the end of the RCT phase with each of the stakeholder groups will help us to plan our next steps for dissemination.

Limitations

Our development process was not without limitations. First, the patient population at the academic hospital where we developed the app is homogeneous. Most patients identify as white and non-Hispanic and have higher income and education levels than average for the greater Boston area where the hospital is located. Furthermore, including only patients with iPhone or Android smartphones biases our sample toward younger, wealthier, and better educated individuals. Therefore, our findings in the development process and the RCT may not be applicable to broader populations. However, we did recruit a diverse sample of stakeholders, representing many disciplines and professions, community and academic medical centers, and geographical locations. Additionally, acknowledging this limitation we later deployed the app on data-enabled tablets and had these tablets available for study participants who did not have a compatible smartphone.

CORA would ideally upload weekly symptom reports directly into patient charts in the electronic health record (EHR) so that oncologists can easily consult them when reviewing a chart before or during the patient's visit. Unfortunately, logistical limitations of the EHR system in use at the study sites prevented us from delivering symptom reports to clinicians in a way that would be most convenient for them. We sent symptom reports to oncologists by HIPAA-compliant email instead. Thus, we cannot guarantee that oncologists open the symptom report emails that we send them. As more flexible EHRs are developed [29,30] and patient-reported outcomes are integrated into cancer care [31,32] we expect that this barrier to effectively communicating patient symptom trends to oncologists will be removed in future studies.

A methodological limitation is that we did not collect quantitative usage or acceptability data during the development and preliminary testing phase. Surveys probing user acceptability of the CORA app and its modules would have provided useful information for refining the app and justifying its readiness for deployment in an RCT. We have addressed this lack of quantitative feedback data by including app usability and acceptability questions in the RCT. These data will inform how we change and improve future versions of CORA. Likewise, it would have been optimal to collect demographic data from our stakeholders; unfortunately, this was not possible as stakeholders were considered as study team members rather than participants. Ethically, we could not collect personal data from individuals who were not formally consented through IRB processes. However, we did collect demographic information from patients and clinicians who consented as study participants to review the app wireframes. Future studies should seek to create arrangements with funding agencies and IRBs that enable collection of basic demographic information from all stakeholders.

A final limitation is that the version of CORA described in this manuscript does not support all available smartphone operating systems or wearable activity tracking device brands. While integrating more third-party software with CORA entails considerable engineering efforts, it is critical to support the majority of these devices used by individuals with cancer. We intend to make CORA compatible with more types of smartphone devices and wearable activity trackers.

Comparison With Prior Work

Our development process aligns with the best practices used by teams developing similar apps. Darlow and Wen [16] conducted a review of existing mHealth interventions in oncology and defined a framework for successful mHealth intervention development. Key elements of successful intervention development identified in this review include stakeholder involvement in the development process, addressing the unique needs and experiences of patients and caregivers in the target

population, and ensuring user satisfaction with the system along with perceived benefits and limitations. The review also highlights several frameworks for mHealth intervention development, one of which we consider within the theoretical framework of the present intervention development.

Darlow and Wen's review [16] outlines 8 best practices for the development of mHealth interventions; however, it was published as we were in the final stages of our development process. Despite not being part of our initial aims, our development process met these criteria (Table 4). We engaged stakeholders at all points in development, including health professionals who could ensure that the burden introduced by the intervention would be minimal. Through extensive user testing, we confirmed that our app was simple and intuitive and gave patients a sense of control over their care.

Table 4. Best practices of the development phase.

Best practice criteria	Criteria fulfillment in the Chemotherapy Assistant (CORA)	Input from stakeholders to meet criteria
Use a framework for developing mobile health interventions.	Partially met criterion: we consulted the model of medication adherence proposed by Murray et al [18] in designing our intervention. However, we did not use a model for our mobile development process.	Stakeholders did not participate in this aspect of the development process.
Conduct thorough user testing using mixed methods.	Met criterion: we conducted extensive qualitative interviewing through focus groups and individual interviews. We also conducted quantitative surveys with our stakeholders to elicit their feedback. In the second phase of the study, we are collecting quantitative acceptability and usability data.	Stakeholders provided feedback in focus groups and individual interviews during the development process.
Anticipate and plan for the time it will take to carry out the development testing phases, as well as the time it will take to make revisions to a system in between phases.	Met criterion: we allotted time and funding in our initial grant proposal for development testing with revision between phases.	Stakeholders did not participate in this aspect of the development process.
Engage stakeholders throughout the entire development process.	Met criterion: patient, clinician, and community stakeholder feedback was solicited during conceptualization, pilot testing, and final testing of the app.	We engaged stakeholders throughout the development process. Key feedback items from each stakeholder group were implemented into app features (see Table 2).
Ensure that system is simple and that use is intuitive.	Met criterion: we tested an early version of our app prototype with patient and family member stakeholders, eliciting their feedback to inform revisions.	Feedback on wireframes from patient and family stakeholders demonstrated how to simplify the app design.
System component should instill a sense of competence and agency over patient's own care.	Met criterion: our app enables patients to self-monitor symptom trends and provides advice to help them manage their own symptoms when clinically appropriate.	Feedback from patient and family stakeholders confirmed that our design was acceptable. Feedback from clinicians ensured that patients were provided with timely and accurate information in CORA to manage symptoms.
If health professionals will be needed for system implementation, ensure that any burden is not considerable.	Met criterion: clinicians were included as key stakeholders throughout the development of the app to ensure burden was low. Also, at the start of the trial, we presented our study design to each oncology clinic team at our hospital to ensure clinician acceptability.	Feedback from clinician and practice administrator stakeholders directed how we implemented CORA into clinician workflows.
Publish results of development testing.	Met criterion: this manuscript details the results of our development, pilot testing, and ongoing testing efforts.	Stakeholder feedback collected since completion of the development process has guided how best to describe CORA in this manuscript.

To our knowledge, we are the first to describe the development of an app targeted at promoting adherence to oral chemotherapy for patients with cancer. A recent systematic review describes various interventions to improve adherence to oral chemotherapies; however, none of these interventions is based in mobile technology [11]. We have also described the development of features to address symptom monitoring and management as well as patient-provider communication, which have been included in previous interventions [33-38]. A recent review of mHealth intervention development suggests that these features are the most frequently included in apps designed for cancer patients [16]. Our app enables EMAs of adherence to medication and symptoms. This represents an improvement in validity over methodologies that rely on retrospective reports of symptoms and adherence and addresses the longstanding need for technologies that provide more granular and accurate data reflecting health behaviors [39,40], including adherence [41].

Lessons Learned and Conclusions

There are a number of ways to streamline app development that we learned in this process. First, it is important to optimize communications between the investigative research team and

the technical development team. Initial development of the app, iterating on the design, and fixing bugs may take longer than the study team anticipates. Research and technical teams may have different perspectives on which bugs and features should be prioritized. Based on our experiences, we would advise that study teams anticipate up to 50% more time for development and iteration of software beyond their initial estimates.

Careful planning by the study team members can mitigate difficulties in development. If the initial specifications for the app do not include requirements for reporting of all needed study data, later development of those reporting systems requires a revision. These types of data reporting systems may require significant changes to back-end databases, and thus may cause delays. Furthermore, we found that it is preferable to generate continuous reports of study data rather than infrequent data extractions. Continuous data enables the study team to conduct data quality assurance checks, minimizing potential loss of data occurring due to bugs in the app. Investigators should refer to the eHealth Consolidated Standards of Reporting Trials document to identify data points to collect for accurate reporting on their app [42].

A final lesson learned is the importance of engaging stakeholders and soliciting their feedback. Beginning with our initial conception of an app targeted toward helping patients track their medications, our stakeholders suggested numerous additions and improvements to the app that would enhance the experience for patients and their clinicians. As a result of stakeholder involvement, the final app is patient-centered, user-friendly, and minimally burdensome to clinicians. Stakeholder engagement is an emerging trend not only in development of mHealth apps but in health interventions and patient-centered outcomes research more generally [43], and we believe our development process provides a template for how stakeholders can be engaged to make health interventions more relevant for patients, clinicians, and health care systems alike.

Future directions in the development of our app include pursuing strategies for health-behavior modification that have proven successful in other apps. For example, we could include functionality to integrate other adherence-promoting technologies with our systems. Electronic pill bottles that track when they are opened and closed (as a proxy for when doses are taken) are now widely available as commercial products—for example, the Medication Event Monitoring System. Integrating these technologies with our software could enable patients and clinicians to check via their mobile phones or online portals whether scheduled doses have been taken. Such a system could even upload adherence data to a hospitals electronic medical record and send email or text message notifications to patients and clinicians after missed doses. We also could provide more mechanisms for rewarding user engagement in the app, such as by gamifying the app. Gamification is the application of video game elements, such as embarking on quests and earning trophies or badges, in contexts such as health care [44,45]. Using CORA, a patient could earn an in-app badge or even a real-world reward such as a gift card or discount coupon at a local pharmacy for completing a week with no missed doses.

In addition, given the integral role of caregivers in patient care, features could be added that aid the caregiver in caring for their loved one. For example, a version of CORA designed for caregivers could enable caregivers to set reminders for appointments and medication administration, rate patient symptoms, receive feedback for how to help their loved one manage symptoms, and access tips for caregiver self-care. Future versions of our app could incorporate these and other strategies to improve adherence to oral chemotherapy. Results of our ongoing RCT will inform next steps in app development as well as future research questions.

We have developed a novel app to improve oral chemotherapy adherence and detailed the iterative process here. In developing the app, we engaged stakeholders from across the continuum of care and followed a design process of iteration and usability testing with patients. We will build upon this work through validation of our app in an RCT and developing this app toward wide dissemination to individuals receiving oral chemotherapy treatment.

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Conflicts of Interest

None declared.

References

1. Weingart SN, Brown E, Bach PB, Eng K, Johnson SA, Kuzel TM, et al. NCCN Task Force Report: Oral chemotherapy. J Natl Compr Canc Netw 2008 Mar;6 Suppl 3:S1-S14. [Medline: 18377852]
2. Liu G, Franssen E, Fitch MI, Warner E. Patient preferences for oral versus intravenous palliative chemotherapy. J Clin Oncol 1997 Jan;15(1):110-115. [Medline: 8996131]

3. Paley M, Love N, Carlson R, Tripathy D, Kaderman R, Dvorkin J, et al. Preferences for oral and parenteral antitumor therapy: a survey of 260 patients with metastatic breast cancer. J Clin Oncol (Meeting Abstracts) 2005:619. [doi: 10.1200/jco.2005.23.16_suppl.619]
4. Payne SA. A study of quality of life in cancer patients receiving palliative chemotherapy. Soc Sci Med 1992 Dec;35(12):1505-1509. [Medline: 1283035]
5. Borner MM, Schoffski P, de Wit R, Caponigro F, Comella G, Sulkes A, et al. Patient preference and pharmacokinetics of oral modulated UFT versus intravenous fluorouracil and leucovorin: a randomised crossover trial in advanced colorectal cancer. Eur J Cancer 2002 Feb;38(3):349-358. [Medline: 11818199]
6. Banna GL, Collovà E, Gebbia V, Lipari H, Giuffrida P, Cavallaro S, et al. Anticancer oral therapy: emerging related issues. Cancer Treat Rev 2010 Dec;36(8):595-605. [doi: 10.1016/j.ctrv.2010.04.005] [Medline: 20570443]
7. Partridge AH, Avorn J, Wang PS, Winer EP. Adherence to therapy with oral antineoplastic agents. J Natl Cancer Inst 2002 May 1;94(9):652-661 [FREE Full text] [Medline: 11983753]
8. Ruddy K, Mayer E, Partridge A. Patient adherence and persistence with oral anticancer treatment. CA Cancer J Clin 2009;59(1):56-66 [FREE Full text] [doi: 10.3322/caac.20004] [Medline: 19147869]
9. Escalada P, Griffiths P. Do people with cancer comply with oral chemotherapy treatments? Br J Community Nurs 2006 Dec;11(12):532-536. [doi: 10.12968/bjcn.2006.11.12.22424] [Medline: 17170677]
10. Wood L. A review on adherence management in patients on oral cancer therapies. Eur J Oncol Nurs 2012 Sep;16(4):432-438. [doi: 10.1016/j.ejon.2011.10.002] [Medline: 22051845]
11. Greer JA, Amoyal N, Nisotel L, Fishbein JN, MacDonald J, Stagl J, et al. A systematic review of adherence to oral antineoplastic therapies. Oncologist 2016 Mar;21(3):354-376. [doi: 10.1634/theoncologist.2015-0405] [Medline: 26921292]
12. Steinhubl SR, Muse ED, Topol EJ. Can mobile health technologies transform health care? JAMA 2013 Dec 11;310(22):2395-2396. [doi: 10.1001/jama.2013.281078] [Medline: 24158428]
13. Heron KE, Smyth JM. Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. Br J Health Psychol 2010 Feb;15(Pt 1):1-39 [FREE Full text] [doi: 10.1348/135910709X466063] [Medline: 19646331]
14. Simoni JM, Huh D, Frick PA, Pearson CR, Andrasik MP, Dunbar PJ, et al. Peer support and pager messaging to promote antiretroviral modifying therapy in Seattle: a randomized controlled trial. J Acquir Immune Defic Syndr 2009 Dec 1;52(4):465-473 [FREE Full text] [Medline: 19911481]
15. DeKoekkoek T, Given B, Given CW, Ridenour K, Schueller M, Spoelstra SL. mHealth SMS text messaging interventions and to promote medication adherence: an integrative review. J Clin Nurs 2015 Oct;24(19-20):2722-2735. [doi: 10.1111/jocn.12918] [Medline: 26216256]
16. Darlow S, Wen K. Development testing of mobile health interventions for cancer patient self-management: A review. Health Informatics J 2015 Apr 27:1-18. [doi: 10.1177/1460458215577994] [Medline: 25916831]
17. Ernst LL, Harden CL, Pennell PB, Llewellyn N, Lau C, Barnard S, et al. Medication adherence in women with epilepsy who are planning pregnancy. Epilepsia 2016 Oct 25. [doi: 10.1111/epi.13586] [Medline: 27778312]
18. Kreyenbuhl J, Record EJ, Himelhoch S, Charlotte M, Palmer-Bacon J, Dixon LB, et al. Development and feasibility testing of a smartphone intervention to improve adherence to antipsychotic medications. Clin Schizophr Relat Psychoses 2016 Jul 25. [doi: 10.3371/CSRP.KRRE.070816] [Medline: 27454213]
19. Lakshminarayana R, Wang D, Burn D, Chaudhuri KR, Cummins G, Galtrey C, The SMART-PD Investigators. Smartphone- and Internet-assisted self-management and adherence tools to manage Parkinson's disease (SMART-PD): study protocol for a randomised controlled trial. Trials 2014;15:374 [FREE Full text] [doi: 10.1186/1745-6215-15-374] [Medline: 25257518]
20. Patel S, Jacobus-Kantor L, Marshall L, Ritchie C, Kaplinski M, Khurana PS, et al. Mobilizing your medications: an automated medication reminder application for mobile phones and hypertension medication adherence in a high-risk urban population. J Diabetes Sci Technol 2013 May 01;7(3):630-639 [FREE Full text] [Medline: 23759395]
21. Perera AI, Thomas MG, Moore JO, Faasse K, Petrie KJ. Effect of a smartphone application incorporating personalized health-related imagery on adherence to antiretroviral therapy: a randomized clinical trial. AIDS Patient Care STDS 2014 Nov;28(11):579-586 [FREE Full text] [doi: 10.1089/apc.2014.0156] [Medline: 25290556]
22. Sarzynski E, Decker B, Thul A, Weismantel D, Melaragni R, Cholakis E, et al. Beta testing a novel smartphone application to improve medication adherence. Telemed J E Health 2016 Aug 26. [doi: 10.1089/tmj.2016.0100] [Medline: 27564971]
23. Mohr DC, Schueller SM, Montague E, Burns MN, Rashidi P. The behavioral intervention technology model: an integrated conceptual and technological framework for eHealth and mHealth interventions. J Med Internet Res 2014;16(6):e146 [FREE Full text] [doi: 10.2196/jmir.3077] [Medline: 24905070]
24. Whittaker R, Merry S, Dorey E, Maddison R. A development and evaluation process for mHealth interventions: examples from New Zealand. J Health Commun 2012;17 Suppl 1:11-21. [doi: 10.1080/10810730.2011.649103] [Medline: 22548594]
25. Murray MD, Morrow DG, Weiner M, Clark DO, Tu W, Deer MM, et al. A conceptual framework to study medication adherence in older adults. Am J Geriatr Pharmacother 2004 Mar;2(1):36-43. [Medline: 15555477]
26. Highland J, Clemens H, Loren L, Roberts J. Actuarial assessment of Senate Bill 1070: An Act Relative to Oral Cancer Therapy. 2012 Jun. URL: http://www.chiamass.gov/assets/docs/r/pubs/12/mb-oral-cancer-therapy-actuarial.pdf [accessed 2016-03-04] [WebCite Cache ID 6flFh3XRp]

27. Borner MM, Dietrich D, Stupp R, Morant R, Honegger H, Wernli M, et al. Phase II study of capecitabine and oxaliplatin in first- and second-line treatment of advanced or metastatic colorectal cancer. J Clin Oncol 2002 Apr 1;20(7):1759-1766. [Medline: 11919232]
28. O'Neill VJ, Twelves CJ. Oral cancer treatment: developments in chemotherapy and beyond. Br J Cancer 2002 Oct 21;87(9):933-937 [FREE Full text] [doi: 10.1038/sj.bjc.6600591] [Medline: 12434279]
29. Mirkovic J, Kaufman DR, Ruland CM. Supporting cancer patients in illness management: usability evaluation of a mobile app. JMIR Mhealth Uhealth 2014;2(3):e33 [FREE Full text] [doi: 10.2196/mhealth.3359] [Medline: 25119490]
30. Glasgow RE, Kaplan RM, Ockene JK, Fisher EB, Emmons KM. Patient-reported measures of psychosocial issues and health behavior should be added to electronic health records. Health Aff (Millwood) 2012 Mar;31(3):497-504 [FREE Full text] [doi: 10.1377/hlthaff.2010.1295] [Medline: 22392660]
31. Wu AW, Kharrazi H, Boulware LE, Snyder CF. Measure once, cut twice—adding patient-reported outcome measures to the electronic health record for comparative effectiveness research. J Clin Epidemiol 2013 Aug;66(8 Suppl):S12-S20 [FREE Full text] [doi: 10.1016/j.jclinepi.2013.04.005] [Medline: 23849145]
32. Partridge AH, Seah DSE, King T, Leighl NB, Hauke R, Wollins DS, et al. Developing a service model that integrates palliative care throughout cancer care: the time is now. J Clin Oncol 2014 Oct 10;32(29):3330-3336. [doi: 10.1200/JCO.2013.54.8149] [Medline: 25199756]
33. Smith TG, Castro KM, Troeschel AN, Arora NK, Lipscomb J, Jones SM, et al. The rationale for patient-reported outcomes surveillance in cancer and a reproducible method for achieving it. Cancer 2016 Feb 01;122(3):344-351. [doi: 10.1002/cncr.29767] [Medline: 26619031]
34. Maguire R, Ream E, Richardson A, Connaghan J, Johnston B, Kotronoulas G, et al. Development of a novel remote patient monitoring system: the advanced symptom management system for radiotherapy to improve the symptom experience of patients with lung cancer receiving radiotherapy. Cancer Nurs 2015;38(2):E37-E47. [doi: 10.1097/NCC.0000000000000150] [Medline: 24836956]
35. Yap KY, Low HX, Koh KS, Un M, Shih V, Chan A. Feasibility and acceptance of a pharmacist-run tele-oncology service for chemotherapy-induced nausea and vomiting in ambulatory cancer patients. Telemed J E Health 2013 May;19(5):387-395. [doi: 10.1089/tmj.2012.0136] [Medline: 23531095]
36. Kearney N, Kidd L, Miller M, Sage M, Khorrami J, McGee M, et al. Utilising handheld computers to monitor and support patients receiving chemotherapy: results of a UK-based feasibility study. Support Care Cancer 2006 Jul;14(7):742-752. [doi: 10.1007/s00520-005-0002-9] [Medline: 16525792]
37. Weaver A, Young AM, Rowntree J, Townsend N, Pearson S, Smith J, et al. Application of mobile phone technology for managing chemotherapy-associated side-effects. Ann Oncol 2007 Nov;18(11):1887-1892 [FREE Full text] [doi: 10.1093/annonc/mdm354] [Medline: 17921245]
38. McGee M, Gray P. A handheld chemotherapy symptom management system: results from a preliminary outpatient field trial. Health Informatics J 2005;11(4):243-258.
39. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annu Rev Clin Psychol 2008;4:1-32. [Medline: 18509902]
40. Stone AA, Shiffman S. Ecological momentary assessment (EMA) in behavioral medicine. Ann Behav Med 1994;16(3):199-202.
41. Stirratt MJ, Dunbar-Jacob J, Crane HM, Simoni JM, Czajkowski S, Hilliard ME, et al. Self-report measures of medication adherence behavior: recommendations on optimal use. Transl Behav Med 2015 Dec;5(4):470-482 [FREE Full text] [doi: 10.1007/s13142-015-0315-2] [Medline: 26622919]
42. Eysenbach G. CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. J Med Internet Res 2011;13(4):e126 [FREE Full text] [doi: 10.2196/jmir.1923] [Medline: 22209829]
43. Frank L, Basch E, Selby JV, Patient-Centered Outcomes Research Institute. The PCORI perspective on patient-centered outcomes research. JAMA 2014 Oct 15;312(15):1513-1514. [doi: 10.1001/jama.2014.11100] [Medline: 25167382]
44. Deterding S, Dixon D, Khaled R, Nacke L. From game design elements to gamefulness: defining gamification. 2011 Presented at: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments; 2011; Tampere.
45. Miller AS, Cafazzo JA, Seto E. A game plan: gamification design principles in mHealth applications for chronic disease management. Health Informatics J 2014 Jul 1:184-193. [doi: 10.1177/1460458214537511] [Medline: 24986104]

Abbreviations

CORA: Chemotherapy Assistant
EHR: electronic health record
EMA: ecological momentary assessment
EMI: ecological momentary intervention
HIPAA: Health Insurance Portability and Accountability Act
IRB: institutional review board

LAMP: Linux, Apache, MySQL, Perl/PHP/Python
MGH: Massachusetts General Hospital
mHealth: mobile health
RCT: randomized controlled trial
UAT: user acceptance testing

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Original Paper

Testing the Feasibility and Usability of a Novel Smartphone-Based Self-Management Support System for Dialysis Patients: A Pilot Study

Aki Hayashi[1*], MD, PhD; Satoko Yamaguchi[1*], MD, PhD; Kayo Waki[1,2], MPH, MD, PhD; Katsuhito Fujiu[1,3], MD, PhD; Norio Hanafusa[4,5], MD, PhD; Takahiro Nishi[6], MD; Hyoe Tomita[7], MD, PhD; Haruka Kobayashi[8], BS; Hideo Fujita[1], MD, PhD; Takashi Kadowaki[2], MD, PhD; Masaomi Nangaku[9], MD, PhD; Kazuhiko Ohe[10], MD, PhD

[1]Department of Ubiquitous Health Informatics, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[2]Department of Diabetes and Metabolic Diseases, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[3]Department of Cardiovascular Medicine, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[4]Division of Total Renal Care Medicine, The University of Tokyo Hospital, Tokyo, Japan
[5]Department of Blood Purification, Kidney Center, Tokyo Women's Medical University, Tokyo, Japan
[6]Nishi Clinic, Tokyo, Japan
[7]Yuujin Clinic, Tokyo, Japan
[8]Business Development of Healthcare Business Smart-Life Solutions Department, NTT DOCOMO, Inc, Tokyo, Japan
[9]Division of Nephrology and Endocrinology, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[10]Department of Biomedical Informatics, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[*]these authors contributed equally

Corresponding Author:
Kayo Waki, MPH, MD, PhD
Department of Ubiquitous Health Informatics
Graduate School of Medicine
The University of Tokyo
7-3-1, Hongo, Bunkyo-ku
Tokyo,
Japan
Phone: 81 3 3815 5411 ext 34462
Fax: 81 3 5800 9129
Email: kwaki-tky@umin.ac.jp

Abstract

Background: Diet and fluid restrictions that need continuous self-management are among the most difficult aspects of dialysis treatment. Smartphone applications may be useful for supporting self-management.

Objective: Our objective is to investigate the feasibility and usability of a novel smartphone-based self-management support system for dialysis patients.

Methods: We developed the Self-Management and Recording System for Dialysis (SMART-D), which supports self-monitoring of three mortality-related factors that can be modified by lifestyle: interdialytic weight gain and predialysis serum potassium and phosphorus concentrations. Data is displayed graphically, with all data evaluated automatically to determine whether they achieve the values suggested by the Japanese Society for Dialysis Therapy guidelines. In a pilot study, 9 dialysis patients used SMART-D system for 2 weeks. A total of 7 of them completed questionnaires rating their assessment of SMART-D's usability and their satisfaction with the system. In addition, the Kidney Disease Quality of Life scale was compared before and after the study period.

Results: All 9 participants were able to use SMART-D with no major problems. Completion rates for body weight, pre- and postdialysis weight, and serum potassium and phosphorus concentrations were, respectively, 89% (SD 23), 95% (SD 7), and 78% (SD 44). Of the 7 participants who completed the usability survey, all were motivated by the sense of security derived from using the system, and 6 of the 7 (86%) reported that using SMART-D helped improve their lifestyle and self-management.

Conclusions: Using SMART-D was feasible, and the system was well regarded by patients. Further study with larger scale cohorts and longer study and follow-up periods is needed to evaluate the effects of SMART-D on clinical outcomes and quality of life.

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KEYWORDS

telemedicine; mobile phone app; hemodialysis; self-management

Introduction

Management of fluids, sodium, serum potassium, and phosphorus is critical in dialysis therapy. Excessive amounts of any of these may lead to dialysis-related complications such as heart failure, which has been identified as one of the risk factors in dialysis for mortality [1-3]. As a consequence, patients on dialysis are prescribed a diet therapy that restricts intake of sodium, potassium, phosphorus, and fluids. Poor adherence to that diet increases the risk of progression of hypertension and cardiovascular disease, eventually resulting in heart failure, which increases the mortality rate [2,4-6].

Interdialytic weight gain (IWG)—which is measured as (current predialysis weight – previous postdialysis weight)/dry weight × 100—is an indicator of patient adherence to diet therapy, reflecting their sodium and fluid intake. It is also important in itself because IWG is associated with blood pressure and mortality [1,5]. Moreover, increase in percentage of IWG is associated with an increase in predialysis systolic blood pressure [4].

Serum potassium and phosphorus levels are also good indicators of dialysis patient adherence to a diet therapy, and they are also associated with mortality. A recent study reported that higher potassium intake is associated with increased death risk [7]. Similarly, looking at mineral values, phosphorus level is considered the strongest predictor of mortality for dialysis patients [3,8]. Accordingly, dialysis patients are advised to restrict protein intake and avoid processed foods.

That is easier said than done. Patients receiving hemodialysis often display great difficulty in adhering to a diet therapy that requires strict and continued self-management over a long period of time. The very mechanics of self-management make adherence difficult. Some patients record their body weight and dietary content in a paper diary. But recording data that way is unrewarding because it does not let patients know whether they are achieving target values or let them easily track changes in the data. Systems that do facilitate such understanding of patients' current status and changes in it may motivate patients, leading to better self-management with improved adherence to diet therapy and improved survival.

Improving quality of life (QOL) is also crucial for dialysis patients because health-related QOL as measured by the Kidney Disease Quality of Life Short Form (KDQOL-SF)[9,10] was shown to be a predictor of mortality and hospitalization in dialysis patients, even after taking into account other risk factors [11,12]. Improving self-management is an effective way to improve QOL for hemodialysis patients [13-15], raising the expectations that tools to help self-management may be effective in improving their QOL.

It was obvious that recent developments in mobile technology—such as smartphone and tablet computer apps—could be the basis for developing a platform for systems to improve self-management of chronic disease. We developed DialBetics, a novel smartphone-based self-management support system for type 2 diabetes patients that provides those patients with real-time advice on diet and lifestyle based on the patients' at-home measurements and input [16]. The system significantly improved glycemic control by helping patients improve self-management skills.

Given the importance of self-management for dialysis patients, similar self-management support systems are likely to be effective, and, indeed, there have been a few reports of success with self-management support systems for dialysis patients based on mobile technology. Sevick et al [17] reported a case in which a dietary self-monitoring system based on a personal digital assistant (PDA) device augmented by a dietician's behavioral counseling was effective in reducing IWG and alleviating hyperphosphatemia and hyperkalemia. Connelly et al [18] reported the effect of a mobile app for hemodialysis patients that assisted them in recording their dietary intake and showed them their consumption levels of fluid, sodium, and potassium: 12 of 18 of those patients said that the app helped them modify their diet.

Although these reports are encouraging, the systems involved are relatively complicated and painstaking; patients must faithfully enter every detail of their daily meals. To help improve adherence by hemodialysis patients in the long term, we felt that a simpler system might be preferable.

To that end, we developed the Self-Management and Recording System for Dialysis (SMART-D), a simple smartphone-based system focused on three key factors—IWG, potassium, and phosphorus—that are associated with mortality but are modifiable by improving diet. SMART-D helps patients record body weight, predialysis serum potassium, and phosphorus concentrations with reference to target values with all recorded data displayed in a line chart so patients can recognize at a glance any changes and see whether they are meeting those target values. We conducted a pilot study to evaluate the feasibility and usability of the system for patients at two dialysis facilities in Tokyo.

Methods

Design of the Self-Management and Recording System for Dialysis

The system is composed of two modules (Figure 1). The first—the data management and evaluation module—is for entry of patients' body weight, serum potassium, and phosphorus concentrations. Body weight (measured twice a day, in the morning and the afternoon) is either automatically transferred by Bluetooth from the weight scale to the patients' smartphone or entered manually by the patients. When entered manually, if the weight does not seem consonant with the patient's other recent entries—if it is unreasonably high or low—the smartphone gives an alert to notify the patient of a possible inputting error. Patients manually enter their predialysis serum potassium and phosphorus concentrations; these come from blood tests at their clinic visits (generally every 2 weeks) where they usually receive the full results of the tests. All the data are automatically evaluated according to target values and displayed as a graph so patients can track the day-to-day trend of their weight and the general trend of their potassium and phosphorus levels. Body weight, IWG, and serum phosphorus concentrations are evaluated based on the Japanese Society for Dialysis Therapy (JSDT) guidelines; serum potassium concentrations are evaluated based on annual statistics provided by the JSDT. Optimally, IWG is <3% of the dry weight (DW) when the interval between dialysis sessions is one day and <6% of the DW when the interval is 2 days; serum potassium concentrations are ≥3.5 mEq/L and ≤5.5 mEq/L; serum phosphorus concentrations are ≥3.5 mg/dL and ≤6.0 mg/dL (Figure 2). To help patients monitor their status at a glance, the background of the graph is color-coded: blue if within the range of target values, yellow if marginally outside, and red if seriously outside the target values for body weight (specifically, blue if ≥100% and <103% of DW, yellow if ≥103% and <106% of DW, red if <100% or ≥106% of DW; for potassium, blue if ≥3.5 and ≤5.5 mEq/L, yellow if ≥3.0 and <3.5/>5.5 and <6.0 mEq/L, red if <3.0 or >6.0 mEq/L; and for phosphorus, blue if ≥3.5 and ≤6.0 mg/dL, yellow if ≥2.0 and <3.5/>6.0 and ≤8.0 mg/dL, red if <2.0 or >8.0 mg/dL).

All data are automatically sent by the smartphone to the medical staff administrator module, SMART-D's second module, which allows the medical staff in dialysis facilities to monitor the data transferred from each patient's data management and evaluation module and give advice on intake if the readings suggest that intervention is advisable. Patient use of the system is output by a comma-separated values (CSV) file, so how often patients input data and how often they checked their data can also be monitored.

Figure 1. An overview of the Self-Management and Recording System for Dialysis.

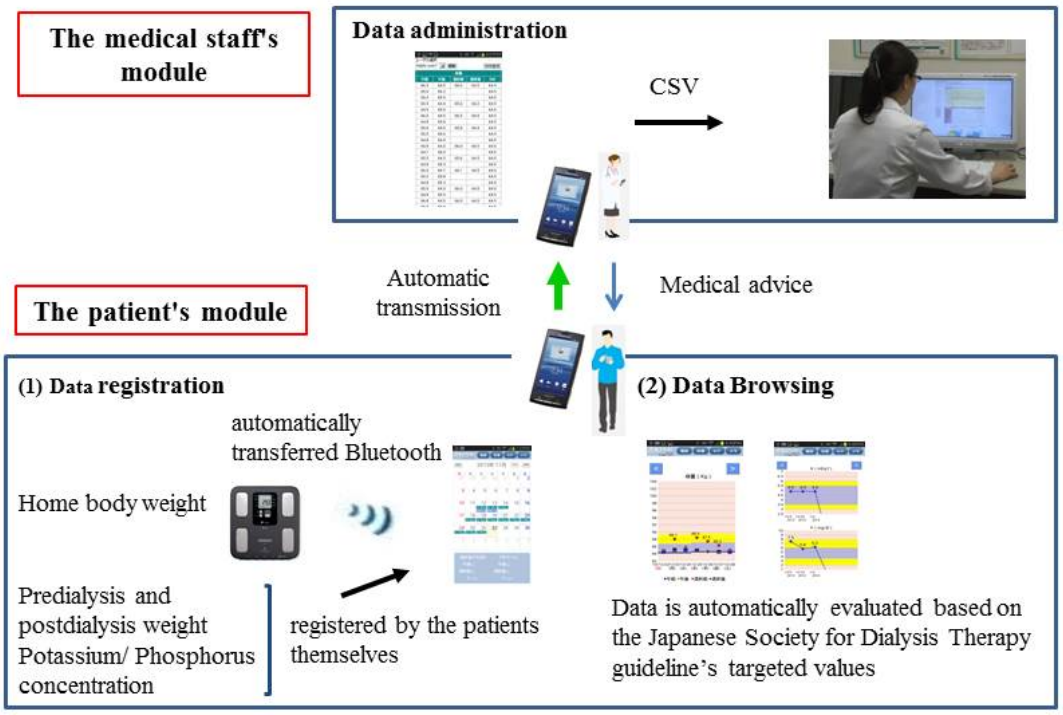
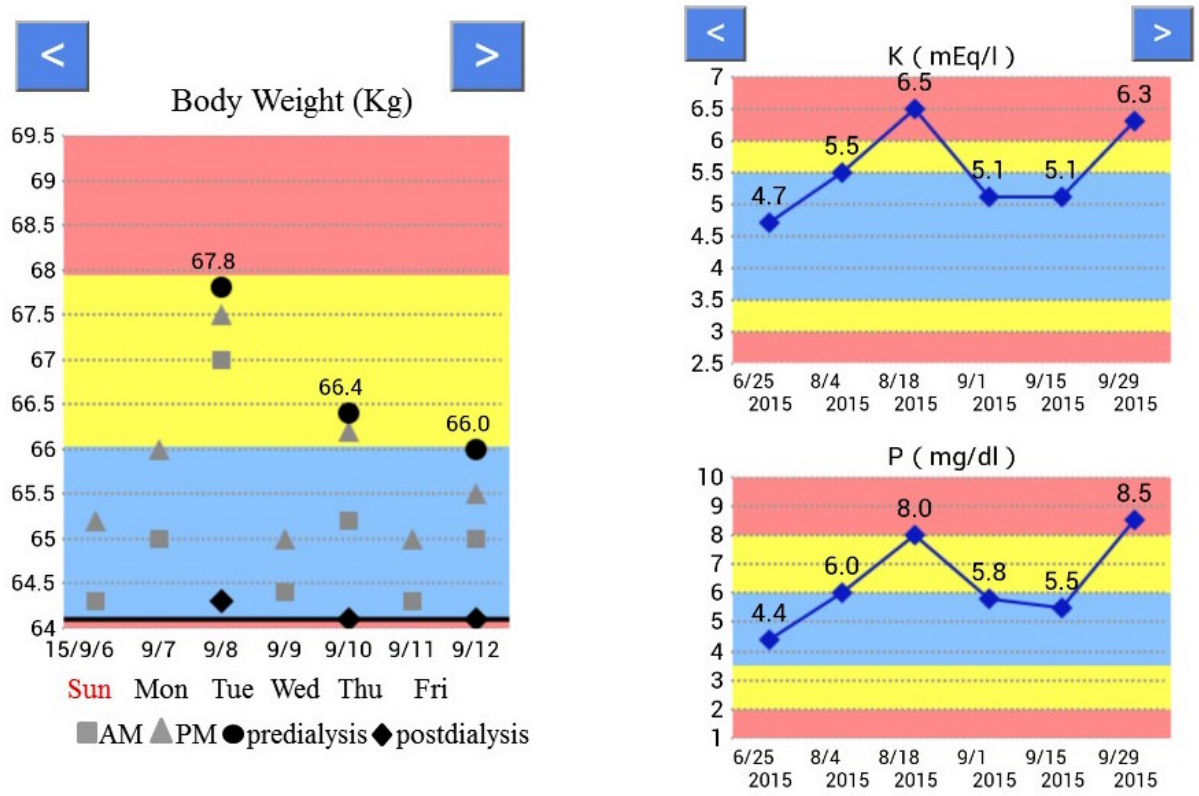


Figure 2. Sample view of the Self-Management and Recording System for Dialysis screen.



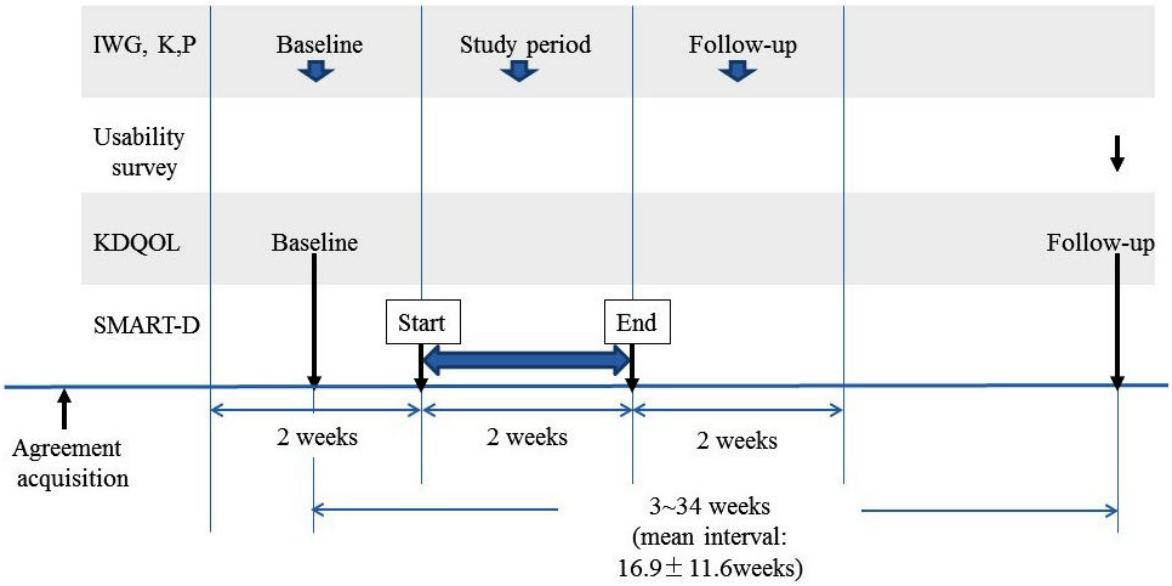
Study Design and Participants

A questionnaire survey about QOL and a 2-week pilot study whose purpose was to evaluate the feasibility and usability of the system were designed and approved by the Institutional Review Board of the University of Tokyo Hospital. Participants were recruited at two outpatient hemodialysis facilities in Tokyo, with written informed consent obtained from all. To be eligible as participants, patients had to have end-stage renal disease—having received outpatient hemodialysis treatment for at least 2 years—and be aged 20 years or older with an average IWG rate >5% of DW and serum potassium concentration >5.5 mEq/L or serum phosphorus concentration >6 mg/dL when the interval between dialysis sessions was 2 days. Patients who proved unable to use a smartphone correctly because of dementia, vision disorder, or other reasons were excluded. A total of 20 patients agreed to participate in the survey; of those, 9 who were willing to participate in the pilot study using SMART-D were assigned to the SMART-D group. A total of 11 patients who did not wish to use SMART-D but agreed to give their clinical data (IWG, serum potassium, and phosphorus concentration) and to complete the survey were assigned to the non–SMART-D group. All participants would continue their regular dialysis treatment 3 times a week. There were roughly the same number of each group at each dialysis facility. However, those using SMART-D at one dialysis facility used it for 2 weeks from March to April 2014, and those at the other dialysis facility used SMART-D for 2 weeks from September to October 2014. The IWG, serum potassium, and phosphorus concentrations at baseline and follow-up periods were taken, respectively, 2 weeks before and after the study period.

The research team included a nephrologist and system administration specialists, experts in technical and database apps, and a research nurse. The questionnaire survey that patients completed was the Japanese version of the questionnaire summary of dialysis self-care activities and the KDQOL-SF version 1.3 [19]; the survey was made both before and after the study period (the mean interval was 16.9 [SD 11.6] weeks) (Figure 3). One participant in the SMART-D group was hospitalized and one in the non–SMART-D group changed dialysis facilities before completion of the KDQOL during follow-up. This means that only 8 SMART-D users and 10 non–SMART-D users completed the Japanese version of the KDQOL after the study period.

For each participant in the SMART-D group, frequency of the SMART-D use was evaluated by completion rates for body weight in the morning and the afternoon, predialysis and postdialysis weight, and serum potassium and phosphorus concentrations. Completion rates of body weight in the morning and the afternoon, predialysis and postdialysis weight and serum potassium and phosphorus concentrations were calculated as (1) number of entries/(number of days × 2) × 100, (2) number of entries/(number of dialysis days × 2) × 100, and (3) number of entries/number of blood-test days × 100.

Figure 3. Timeline of the study.



Questionnaires rating participant assessment of SMART-D's usability and their satisfaction with the system were collected after the study ended (Figure 3). Of the 9 SMART-D users, one was hospitalized as mentioned above and one did not complete the usability survey because that participant dropped out before completion of the survey, so only 7 SMART-D users completed the questionnaires.

Study Methods

Participants in the SMART-D group received a smartphone (Samsung GALAXY Note II SC-02E) and the scale paired with the smartphone (Omron HBF-206IT). In this study, body weight of SMART-D users was measured at home every day and automatically transmitted to the smartphone. On dialysis days, the SMART-D group measured their body weight before and after dialysis. They also entered their predialysis blood test results. Participants in the non–SMART-D group followed their usual self-care regimen.

Members of the SMART-D group were asked to contact the research team nurse by smartphone or email only for technical questions or if, for some reason, they got a weight-input error alert. For questions related to their health status, they were asked to consult their primary physicians or the staff at the dialysis facility.

Statistical Analysis

Paired *t* tests or Wilcoxon tests were performed to compare IWG, serum potassium concentrations, serum phosphorous concentrations, and KDQOL before and after the study period. Unpaired *t* tests and Fisher exact tests were performed to compare baseline characteristics of the two groups. Repeated measures analysis of variance was performed to compare IWG, serum potassium, and phosphorus concentrations at baseline, study period, and follow-up period. We considered *P* values <.05 statistically significant. All statistical analyses were performed with Excel (Microsoft Corp) or EZR (Saitama Medical Center) [20].

Results

Baseline Characteristics

Demographic characteristics of the 9 participants in the SMART-D group are shown in Table 1. The mean age was 47.9 (SD 14.4) years, with the average dialysis vintage being 6.0 (SD 2.9) years. All participants had been receiving dialysis 3 times a week. Their average IWG was 2.2% (SD 0.4) DW/day, average hemoglobin level 10.8 (SD 0.6) g/dL, serum albumin concentration 3.7 (SD 0.2) g/dL, serum potassium concentration 4.9 (SD 0.6) mEq/L, and serum phosphorus concentration 5.4 (SD 1.2) mg/dL. The average number of body weight measurements per day was 1.2 (SD 1.3). Of 9 participants, 7 (78%) were users of a smartphone, PDA, and the Internet, while 2 (22%) were users of a feature phone and nonusers of the Internet (Table 1).

Their demographic characteristics were compared with those of the non–SMART-D group (n=11) who did not wish to use SMART-D. Patients in the non–SMART-D group were older (60.3 [SD 10.5] years, *P*=.04). Of 11 participants, only 3 (27%) were smartphone and PDA users and 4 (36%) were Internet users (Table 1).

Table 1. Baseline characteristics of the participants in the study.

	Total (n=20)	SMART-D[a] (n=9)	Non–SMART-D (n=11)	*P* value[b]
Demographics				
Sex, n (%)				
Male	13 (65)	6 (67)	7 (64)	>.99
Female	7 (35)	3 (33)	4 (36)	
Age (years), mean (SD)	54.7 (13.6)	47.9 (14.4)	60.3 (10.5)	.04
Medical information				
Dialysis vintage (years), mean (SD)	8.6 (5.6)	6.0 (2.9)	10.7 (6.7)	.15
Hemodialysis frequency in a week, n (%)				>.99
Three times	20 (100)	9 (100)	11 (100)	
Primary cause of end stage renal disease, n (%)				.20
Diabetes mellitus	6 (30)	3 (33)	3 (27)	
Glomerulonephritis	4 (20)	0 (0)	4 (36)	
Nephrosclerosis	4 (20)	3 (33)	1 (9)	
Malignant hypertension	1 (5)	1 (11)	0 (0)	
Polycystic kidney disease	1 (5)	0 (0)	1 (9)	
Rheumatoid arthritis	1 (5)	0 (0)	1 (9)	
Unknown	3 (15)	2 (22)	1 (9)	
Comorbid conditions, n (%)				.85
Diabetes	5 (25)	2 (22)	3 (27)	
Hypertension	15 (75)	8 (89)	7 (64)	
Lipid disorders	2 (10)	1 (11)	1 (9)	
Cardiovascular disease	2 (10)	2 (22)	0 (0)	
Cerebrovascular disease	1 (5)	1 (11)	0 (0)	
Disease status				
Predialysis weight (kg), mean (SD)	69.5 (17.8)	76.4 (20.3)	63.8 (14.0)	.12
IWG[c](%DW[d]/day), mean (SD)	2.2 (0.4)	2.2 (0.4)	2.2 (0.4)	.92
Hemoglobin (g/dL), mean (SD)	11.4 (1.5)	10.8 (0.6)	11.9 (1.8)	.048
Serum albumin concentrations (g/dL), mean (SD)	3.8 (0.2)	3.7 (0.2)	3.8 (0.2)	.24
Serum potassium concentrations (mEq/L), mean (SD)	5.0 (0.7)	4.9 (0.6)	5.1 (0.8)	.40
Serum phosphorus concentrations (mg/dL), mean (SD)	5.2 (1.1)	5.4 (1.2)	5.0 (1.1)	.41
Lifestyle				
Weight measurement frequency per day, mean (SD)	0.9 (1.0)	1.2 (1.3)	0.6 (0.7)	.32
Cell phone user, n (%)				.07
Feature phone	9 (45)	2 (22)	7 (64)	
Smartphone	10 (50)	7 (78)	3 (27)	
Non–cell phone user	1 (5)	0 (0)	1 (9)	
Portable digital assistant user, n (%)	10 (50)	7 (78)	3 (27)	.07
Internet user, n (%)	11 (55)	7 (78)	4 (36)	.09

[a]SMART-D: Self-Management and Recording System for Dialysis.

[b]*P* value between the SMART-D group and the non–SMART-D group.

[c]IWG: interdialysis weight gain.

[d]DW: dry weight.

Feasibility and Usability

All 9 patients in the SMART-D group were able to complete the 2-week use of the system without any major problems. The mean number of daily entries for the dialysis date when there were 4 items to be entered (body weight in the morning and afternoon, predialysis weight, and postdialysis weight) was 3.9 (SD 0.2). The mean number of daily entries for the nondialysis date when there were 2 items to be entered (body weight in the morning and afternoon) was 1.8 (SD 0.5). The average completion rates for body weight in the morning and the afternoon and predialysis/postdialysis weight were, respectively, 89% (SD 23) and 95% (SD 7). The average completion rate for serum potassium and phosphorus concentrations was 78% (SD 44) (Table 2).

Table 2. Average number of daily entries and completion rates (n=9).

	Mean (SD)
Mean number of daily entries	
Dialysis date (4 items to be entered)	3.9 (0.2)
Nondialysis date (2 items to be entered)	1.8 (0.5)
Completion rate (%)	
Body weight in the morning and the afternoon	89 (23)
Predialysis/postdialysis weight	95 (7)
Serum potassium and phosphorus concentrations	78 (44)

Of the 7 participants who answered an end-of-study usability survey, all were motivated by the sense of security derived from using the system (Table 3). The devices, including smartphone, did not cause physical discomfort to any of the participants. Of the 7 patients, 6 (86%) felt that using the system helped to improve their lifestyle and dialysis self-management and that the system had a positive impact on their dialysis management. The average usage time per day was 7.7 (SD 3.9) minutes, and 6 of the 7 patients (86%) felt the system was worth the time they spent. Only one participant—who took 10 minutes per day—felt that using the system was unduly time-consuming. Of the 7 participants, 5 (71%) were willing to continue to use the system (Table 3), citing such reasons as the way it made self-management easier or motivated them to improve health status (Table 4). One (14%) expressed the desire to continue using it if an additional function could be implemented to enable management of blood pressure and medication, while another patient (14%) was undecided (Tables 3 and 4).

Table 3. Usability survey results.

Statement or question (n=7)	Response
I could use a smartphone with no problem. (n [%])	5 (71)
I could use a weight scale with no problem. (n [%])	6 (86)
The interface of the data registration was easy to use. (n [%])	7 (100)
The interface of the data browsing was easy to watch. (n [%])	6 (86)
The instructions were easy to understand. (n=5[a]) (n [%])	5 (100)
The devices caused me physical discomfort. (n [%])	0 (0)
I easily incorporated using the system into my daily routine. (n [%])	5 (71)
Using the system gave me a sense of security. (n [%])	7 (100)
Participation in the study helped me to improve lifestyle and dialysis self-management. (n [%])	6 (86)
Using the system caused me some problems. (n [%])	1(14)[b]
How much time did you spend using the system per day? (minutes, mean [SD])	7.7 (3.9)
Is the system worth using for the time you spent? (n [%])	6 (86)
Did this system give a positive impact on your dialysis management? (n [%])	6 (86)
Would you like to continue using this system? (n [%])	5 (71)[c]

[a]Two participants answered that they did not use the instructions.

[b]One participant felt that using the SMART-D was time-consuming.

[c]The reasons given by the participants are shown in Table 4.

Table 4. Reasons why the participants would like or not like to continue using the Self-Management and Recording System for Dialysis.

Would you like to continue using this system? (n=7)		
Yes (5)	No (1)	Undecided (1)
Since the water intake of the day can be confirmed at a glance, I can be careful of the water intake.	I would like to continue using it if additional function is implemented to enable management of blood pressure and medication.	Although it is useful for monitoring water intake at a glance, it is sometimes too much work.
It makes self- management easier.		
It helps me motivated to improve my health status.		
Recording the body weight every day enabled me to know the physical condition better.		
Getting aware that the data deviated from the normal range motivated me to make efforts to return to the target range.		
It is convenient because the change of data can be seen immediately.		

The medical staff in the dialysis facilities monitored the data transferred from each patient's module and found no reason to contact the patients outside of the regular dialysis sessions during the 2 weeks.

Clinical Outcomes

For IWG, serum potassium concentrations, and serum phosphorus concentrations, the values during the study and follow-up periods were compared with those at baseline with no significant differences found in the SMART-D group and the non–SMART-D group (Multimedia Appendix 1).

Quality of Life

The QOL before and after the study was evaluated, as noted, by the KDQOL scale, which consists of 79 items, 36 asking about health-related QOL in general (the Medical Outcomes Study SF-36) and 43 asking about QOL as it is affected by kidney disease and by dialysis. The scores range from 0 to 100, with higher scores indicating better QOL [19]. As noted in Methods, 8 patients in the SMART-D group and 10 in the non–SMART-D group completed the questionnaire before and after the study period.

The KDQOL scores of the SMART-D group were compared before and after the study period (Table 5). The Social Functioning score showed a significant change, improving by 9.4 points (mean values 75.0 to 84.4; P=.048), while the other KDQOL scores remained unchanged. In the non–SMART-D group, the Role Functioning Emotional score was lower than in the SMART-D group before the study period (Multimedia Appendix 2), and none of the KDQOL scores improved over time (Multimedia Appendix 3).

Table 5. Comparison of changes in the Kidney Disease Quality of Life scores before and after the study period in the Self-Management and Recording System for Dialysis group (n=8).

Kidney Disease Quality of Life	Baseline score mean (SD)	Follow-up score mean (SD)	*P* value
Symptoms/problems	83.6 (7.8)	84.4 (8.4)	.84
Effect of kidney disease	78.4 (16.3)	79.7 (16.3)	.42
Burden of kidney disease	36.7 (21.8)	38.3 (16.5)	.79
Work status	75.0 (37.8)	75.0 (37.8)	>.99
Cognitive function	87.6 (11.8)	87.5 (12.6)	.52
Quality of social interaction	90.5 (10.1)	86.7 (19.2)	.20
Sleep	58.5 (7.5)	66.9 (18.1)	.16
Social support	68.7 (25.9)	62.5 (36.5)	.58
Dialysis staff encouragement	75.0 (11.6)	82.8 (14.8)	.10
Patient satisfaction	85.4 (16.5)	79.2 (21.3)	.20
Physical functioning	91.3 (7.4)	83.8 (20.0)	.28
Role functioning physical	78.1 (28.1)	84.4 (35.2)	.67
Bodily pain	65.3 (26.2)	74.1 (25.9)	.17
General health perception	52.9 (16.0)	54.4 (13.5)	.65
Vitality	56.3 (15.8)	65.0 (22.7)	.10
Social functioning	75.0 (20.0)	84.4 (14.6)	.048
Role functioning emotional	91.7 (15.4)	100 (0.0)	.17
Mental health	75.0 (16.1)	74.6 (16.)2	.96

Discussion

Principal Findings

This study has shown the feasibility and usability of SMART-D, a novel smartphone-based self-management system for dialysis patients. Patients record their body weight and predialysis serum potassium and phosphorus concentrations, and the app displays the data in graph form showing automatic evaluation with reference to target values, providing the patients with visual feedback and reinforcement that helps self-monitoring.

The average completion rates for body weight, predialysis/postdialysis weight, and serum potassium and phosphorus concentrations were high: respectively, 89% (SD 23), 95% (SD 7), and 78% (SD 44) (Table 2), proving that SMART-D is a feasible tool. The usability survey demonstrated that participants were comfortable with the use of the system, and most of the participants reported that using the system helped improve their lifestyle and dialysis self-managements and that they wanted to continue using the system (Tables 3 and 4).

The KDQOL scores of the SMART-D group's Social Functioning score improved significantly while their other KDQOL scores remained unchanged (Table 5). This suggests that SMART-D may be effective in improving the QOL of dialysis patients. The clinical relevance of QOL in dialysis patients has been recognized since it was shown to be an independent predictor of mortality and hospitalization [11,12,21]. Improving self-management is an effective way to improve QOL in hemodialysis patients [13-15], and SMART-D may have contributed to improving QOL by supporting self-management. However, this result should be interpreted with caution because the current study was not randomized and had a small sample size with a short study period.

Self-Monitoring and Dialysis

More and more evidence has recently emerged that smartphone-based apps can be powerful tools in supporting self-management for patients with chronic conditions. We have reported on DialBetics, a smartphone-based self-management support system for diabetes patients. DialBetics is an interactive system that provides real-time advice on diet and lifestyle based on input of patient data measured at home including exercise and diet. A 3-month randomized study showed that DialBetics is an effective tool for improving glycemic control [16]. Compared with self-management systems such as DialBetics, SMART-D is a relatively simple system with limited feedback. The system provides no real-time lifestyle advice except when medical staff considers it necessary to intervene with the patients. Rather, the function of SMART-D is to support patient self-monitoring, making it easier and more sustainable for them.

Evidence has suggested that simple self-monitoring is effective for managing various conditions. Obesity is one of them. It was reported that frequent self-weighing by obese patients, accompanied by daily charting of their weight pattern, was effective in weight reduction programs [22,23]. It is interesting and highly relevant that, while increasing patient nutritional education does not necessarily help patients modify behavior

related to obesity in diverse community settings [24], self-weighing—a simple self-monitoring behavior—along with behavioral weight-loss education has proven effective. The power of self-monitoring is quite understandable. With obesity, for instance, self-monitoring promotes greater awareness of how behaviors such as diet and physical activity are impacting weight. Frequent self-weighing provides immediate feedback, helping patients perceive the connection between weight changes and their specific eating behavior and/or lifestyles, making it easier for them to correct these behaviors. Patients who adhere to diets are visibly rewarded by weight loss, and this in turn reinforces adherence to diet and lifestyle changes and, thus, maintenance of weight reduction. Pacanowski and Levitsky [25] reported that frequent self-weighing with visual feedback of weight history—even without any prescribed diet or exercise plan—was effective enough to produce and maintain weight loss. Such is the importance of self-monitoring!

The relevance to hemodialysis is clear. As with obese patients, eating behavior and lifestyle directly impact the body weight and serum potassium and phosphorus concentrations of dialysis patients. Despite repeated attempts to educate such patients about the consequences of noncompliance, their adherence to fluid control and diets that restrict sodium, potassium, and phosphorus intake is generally poor. The SMART-D system helps these patients self-monitor by making it easy for them to view their history of body weight and serum potassium and phosphorus levels with reference to target values. This self-monitoring should help the patients attribute body weight and blood test results to their diet and lifestyle behavior, correct errant behavior, and improve their self-management skills. Medical staff members will also benefit from SMART-D because the system lets them monitor the course of patient at-home body weight and gives them an electronically accurate, objective view of how faithfully patients are measuring their weight and checking their laboratory data, an important insight into patient attitude and seriousness about improving their health status. Combined with access to their own data from the laboratory, this additional information enables medical staff to give patients more precise and appropriate advice on diet and lifestyle.

Limitations

There are several limitations of this study. First, the study period was too short to observe improvement of clinical outcomes although SMART-D is expected to improve clinical outcomes and QOL by supporting self-management; previous studies have reported that apps and programs to improve adherence of dialysis patients to diet and lifestyle changes led to improvement of clinical outcomes and QOL [17,26,27]. Since our study period of 2 weeks was markedly shorter than those of the studies reporting such notable effects, a longer period is necessary to assess the impact of SMART-D on clinical outcomes and QOL. However, we assumed that feasibility and usability could be sufficiently evaluated in a 2-week study period because we had previously successfully evaluated usability and compliance of a smartphone-based self-management tool for type 2 diabetes patients in a 1-week study [28]. Others have also demonstrated the feasibility and acceptability of a mobile phone-based self-management tool for asthma patients in a 2-week study [29]. Even so, a longer study is necessary because it has been reported that the longer a study period becomes, the greater the decline in completion rates [16,30-32].

Second, the overall favorable results of the usability survey might be biased because only those patients willing to use SMART-D were assigned to the SMART-D group while the patients assigned to the non–SMART-D group did not wish to use the system. The differences of demographic characteristics between the two groups are likely to reflect the patient characteristics associated with willingness to use such tools. Patients in the SMART-D group tended to be younger and more likely to be users of a smartphone, PDA, and the Internet (Table 1), suggesting that patients in the SMART-D group had better technology literacy. Future tasks include developing more user-friendly systems that can be widely used by patients with lower information and communication technology literacy.

Conclusions

We have shown the feasibility of SMART-D, a novel smartphone-based self-management system for hemodialysis patients. The system supports self-monitoring of three crucial mortality-related factors that patients can modify by correcting their diet and lifestyle: IWG and predialysis serum potassium and phosphorus concentrations. Most of the participants reported that using SMART-D helped improve their self-management. Further large-scale study with a larger cohort and longer system use and follow-up periods is needed to evaluate the effects of SMART-D on clinical outcomes and QOL.

Acknowledgments

The authors are grateful to the patients who participated in the study for their valuable comments and suggestions about SMART-D. The authors also express their appreciation to all members of the expert panel.

Conflicts of Interest

The study was funded by Pfizer Health Research Foundation and NTT DOCOMO, Inc. AH, SY, KW, KF, and HF are members of the Department of Ubiquitous Health Informatics, which is engaged in a cooperative program between the University of Tokyo and NTT DOCOMO, Inc. KH is an employee of NTT DOCOMO, Inc. NH is a member of the Division of Total Renal Care Medicine, which is supported by Terumo Corp.

Multimedia Appendix 1

Table showing clinical parameters at baseline, study period and follow-up period in the Self-Management and Recording System for Dialysis group (n=9) and the non-Self-Management and Recording System for Dialysis group (n=11).

[PDF File (Adobe PDF File), 20KB - resprot_v6i4e63_app1.pdf]

Multimedia Appendix 2

Table showing comparison of Kidney Disease Quality of Life scores between the Self-Management and Recording System for Dialysis group and the non-Self-Management and Recording System for Dialysis group before the study period.

[PDF File (Adobe PDF File), 33KB - resprot_v6i4e63_app2.pdf]

Multimedia Appendix 3

Table showing comparison of changes in Kidney Disease Quality of Life scores before and after the study period in the non-Self-Management and Recording System for Dialysis group.

[PDF File (Adobe PDF File), 20KB - resprot_v6i4e63_app3.pdf]

References

1. Foley RN, Herzog CA, Collins AJ, United States Renal Data System. Blood pressure and long-term mortality in United States hemodialysis patients: USRDS Waves 3 and 4 Study. Kidney Int 2002 Nov;62(5):1784-1790 [FREE Full text] [doi: 10.1046/j.1523-1755.2002.00636.x] [Medline: 12371980]
2. Kovesdy CP, Regidor DL, Mehrotra R, Jing J, McAllister CJ, Greenland S, et al. Serum and dialysate potassium concentrations and survival in hemodialysis patients. Clin J Am Soc Nephrol 2007 Sep;2(5):999-1007 [FREE Full text] [doi: 10.2215/CJN.04451206] [Medline: 17702709]
3. Tentori F, Blayney MJ, Albert JM, Gillespie BW, Kerr PG, Bommer J, et al. Mortality risk for dialysis patients with different levels of serum calcium, phosphorus, and PTH: the Dialysis Outcomes and Practice Patterns Study (DOPPS). Am J Kidney Dis 2008 Sep;52(3):519-530. [doi: 10.1053/j.ajkd.2008.03.020] [Medline: 18514987]
4. Inrig JK, Patel UD, Gillespie BS, Hasselblad V, Himmelfarb J, Reddan D, et al. Relationship between interdialytic weight gain and blood pressure among prevalent hemodialysis patients. Am J Kidney Dis 2007 Jul;50(1):108-118. [doi: 10.1053/j.ajkd.2007.04.020] [Medline: 17591530]
5. Robinson BM, Tong L, Zhang J, Wolfe RA, Goodkin DA, Greenwood RN, et al. Blood pressure levels and mortality risk among hemodialysis patients in the Dialysis Outcomes and Practice Patterns Study. Kidney Int 2012 Sep;82(5):570-580 [FREE Full text] [doi: 10.1038/ki.2012.136] [Medline: 22718187]
6. Young EW, Albert JM, Satayathum S, Goodkin DA, Pisoni RL, Akiba T, et al. Predictors and consequences of altered mineral metabolism: the Dialysis Outcomes and Practice Patterns Study. Kidney Int 2005 Mar;67(3):1179-1187 [FREE Full text] [doi: 10.1111/j.1523-1755.2005.00185.x] [Medline: 15698460]
7. Noori N, Kalantar-Zadeh K, Kovesdy CP, Murali SB, Bross R, Nissenson AR, et al. Dietary potassium intake and mortality in long-term hemodialysis patients. Am J Kidney Dis 2010 Aug;56(2):338-347 [FREE Full text] [doi: 10.1053/j.ajkd.2010.03.022] [Medline: 20580474]
8. Block GA, Klassen PS, Lazarus JM, Ofsthun N, Lowrie EG, Chertow GM. Mineral metabolism, mortality, and morbidity in maintenance hemodialysis. J Am Soc Nephrol 2004 Aug;15(8):2208-2218 [FREE Full text] [doi: 10.1097/01.ASN.0000133041.27682.A2] [Medline: 15284307]
9. Ware JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992 Jun;30(6):473-483. [Medline: 1593914]
10. Hays RD, Kallich JD, Mapes DL, Coons SJ, Carter WB. Development of the kidney disease quality of life (KDQOL) instrument. Qual Life Res 1994 Oct;3(5):329-338. [Medline: 7841967]
11. Lopes AA, Bragg J, Young E, Goodkin D, Mapes D, Combe C, Dialysis Outcomes and Practice Patterns Study (DOPPS). Depression as a predictor of mortality and hospitalization among hemodialysis patients in the United States and Europe. Kidney Int 2002 Jul;62(1):199-207 [FREE Full text] [doi: 10.1046/j.1523-1755.2002.00411.x] [Medline: 12081579]
12. Mapes DL, Lopes AA, Satayathum S, McCullough KP, Goodkin DA, Locatelli F, et al. Health-related quality of life as a predictor of mortality and hospitalization: the Dialysis Outcomes and Practice Patterns Study (DOPPS). Kidney Int 2003 Jul;64(1):339-349 [FREE Full text] [doi: 10.1046/j.1523-1755.2003.00072.x] [Medline: 12787427]
13. Griva K, Mooppil N, Seet P, Krishnan DSP, James H, Newman SP. The NKF-NUS hemodialysis trial protocol—a randomized controlled trial to determine the effectiveness of a self management intervention for hemodialysis patients. BMC Nephrol 2011 Jan 28;12:4 [FREE Full text] [doi: 10.1186/1471-2369-12-4] [Medline: 21272382]
14. Li H, Jiang Y, Lin C. Factors associated with self-management by people undergoing hemodialysis: a descriptive study. Int J Nurs Stud 2014 Feb;51(2):208-216. [doi: 10.1016/j.ijnurstu.2013.05.012] [Medline: 23768411]

15. Bahadori M, Ghavidel F, Mohammadzadeh S, Ravangard R. The effects of an interventional program based on self-care model on health-related quality of life outcomes in hemodialysis patients. J Educ Health Promot 2014;3:110 [FREE Full text] [doi: 10.4103/2277-9531.145899] [Medline: 25540783]
16. Waki K, Fujita H, Uchimura Y, Omae K, Aramaki E, Kato S, et al. DialBetics: a novel smartphone-based self-management support system for type 2 diabetes patients. J Diabetes Sci Technol 2014 Mar 13;8(2):209-215 [FREE Full text] [doi: 10.1177/1932296814526495] [Medline: 24876569]
17. Sevick MA, Stone RA, Novak M, Piraino B, Snetselaar L, Marsh RM, et al. A PDA-based dietary self-monitoring intervention to reduce sodium intake in an in-center hemodialysis patient. Patient Prefer Adherence 2008 Feb 02;2:177-184 [FREE Full text] [Medline: 19920960]
18. Connelly K, Siek KA, Chaudry B, Jones J, Astroth K, Welch JL. An offline mobile nutrition monitoring intervention for varying-literacy patients receiving hemodialysis: a pilot study examining usage and usability. J Am Med Inform Assoc 2012;19(5):705-712 [FREE Full text] [doi: 10.1136/amiajnl-2011-000732] [Medline: 22582206]
19. Green J, Fukuhara S, Shinzato T, Miura Y, Wada S, Hays RD, et al. Translation, cultural adaptation, and initial reliability and multitrait testing of the Kidney Disease Quality of Life instrument for use in Japan. Qual Life Res 2001;10(1):93-100. [Medline: 11508479]
20. Kanda Y. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. Bone Marrow Transplant 2013 Mar;48(3):452-458 [FREE Full text] [doi: 10.1038/bmt.2012.244] [Medline: 23208313]
21. Mapes DL, Bragg-Gresham JL, Bommer J, Fukuhara S, McKevitt P, Wikström B, et al. Health-related quality of life in the Dialysis Outcomes and Practice Patterns Study (DOPPS). Am J Kidney Dis 2004 Nov;44(5 Suppl 2):54-60. [Medline: 15486875]
22. Fujimoto K, Sakata T, Etou H, Fukagawa K, Ookuma K, Terada K, et al. Charting of daily weight pattern reinforces maintenance of weight reduction in moderately obese patients. Am J Med Sci 1992 Mar;303(3):145-150. [Medline: 1595775]
23. LaRose JG, Lanoye A, Tate DF, Wing RR. Frequency of self-weighing and weight loss outcomes within a brief lifestyle intervention targeting emerging adults. Obes Sci Pract 2016 Mar;2(1):88-92 [FREE Full text] [doi: 10.1002/osp4.24] [Medline: 27668087]
24. Norris SL, Zhang X, Avenell A, Gregg E, Schmid CH, Lau J. Long-term non-pharmacological weight loss interventions for adults with prediabetes. Cochrane Database Syst Rev 2005 Apr 18(2):CD005270. [doi: 10.1002/14651858.CD005270] [Medline: 15846748]
25. Pacanowski CR, Levitsky DA. Frequent self-weighing and visual feedback for weight loss in overweight adults. J Obes 2015;2015 [FREE Full text] [doi: 10.1155/2015/763680] [Medline: 26064677]
26. Barnett T, Li YT, Pinikahana J, Si-Yen T. Fluid compliance among patients having haemodialysis: can an educational programme make a difference? J Adv Nurs 2008 Feb;61(3):300-306. [doi: 10.1111/j.1365-2648.2007.04528.x] [Medline: 18197864]
27. Welch JL, Astroth KS, Perkins SM, Johnson CS, Connelly K, Siek KA, et al. Using a mobile application to self-monitor diet and fluid intake among adults receiving hemodialysis. Res Nurs Health 2013 Jun;36(3):284-298 [FREE Full text] [doi: 10.1002/nur.21539] [Medline: 23512869]
28. Waki K, Aizawa K, Kato S, Fujita H, Lee H, Kobayashi H, et al. DialBetics With a multimedia food recording tool, FoodLog: smartphone-based self-management for type 2 diabetes. J Diabetes Sci Technol 2015 May;9(3):534-540 [FREE Full text] [doi: 10.1177/1932296815579690] [Medline: 25883164]
29. Rhee H, Allen J, Mammen J, Swift M. Mobile phone-based asthma self-management aid for adolescents (mASMAA): a feasibility study. Patient Prefer Adherence 2014;8:63-72 [FREE Full text] [doi: 10.2147/PPA.S53504] [Medline: 24470755]
30. Min YH, Lee JW, Shin Y, Jo M, Sohn G, Lee J, et al. Daily collection of self-reporting sleep disturbance data via a smartphone app in breast cancer patients receiving chemotherapy: a feasibility study. J Med Internet Res 2014;16(5):e135 [FREE Full text] [doi: 10.2196/jmir.3421] [Medline: 24860070]
31. Mummah SA, Mathur M, King AC, Gardner CD, Sutton S. Mobile technology for vegetable consumption: a randomized controlled pilot study in overweight adults. JMIR Mhealth Uhealth 2016 May;4(2):e51 [FREE Full text] [doi: 10.2196/mhealth.5146] [Medline: 27193036]
32. Hartin PJ, Nugent CD, McClean SI, Cleland I, Tschanz JT, Clark CJ, et al. The empowering role of mobile apps in behavior change interventions: the Gray Matters randomized controlled trial. JMIR Mhealth Uhealth 2016 Aug 02;4(3):e93 [FREE Full text] [doi: 10.2196/mhealth.4878] [Medline: 27485822]

Abbreviations

CSV: comma-separated values
DW: dry weight
ICT: information and communication technology
IWG: interdialytic weight gain
JSDT: Japanese Society for Dialysis Therapy
KDQOL: Kidney Disease Quality of Life

KDQOL-SF: Kidney Disease Quality of Life Short Form
PDA: portable digital assistant
QOL: quality of life
SMART-D: Self-Management and Recording System for Dialysis

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Original Paper

The Malaria System MicroApp: A New, Mobile Device-Based Tool for Malaria Diagnosis

Allisson Dantas Oliveira[1,2], MSc; Clara Prats[3], PhD; Mateu Espasa[4], MD; Francesc Zarzuela Serrat[4], MSc; Cristina Montañola Sales[3], PhD; Aroa Silgado[4], BSc; Daniel Lopez Codina[3], PhD; Mercia Eliane Arruda[5,6], PhD; Jordi Gomez i Prat[4], PhD; Jones Albuquerque[1,6], PhD

[1]Federal Rural University of Pernambuco, Department of Statistics and Informatics, Recife, Brazil

[2]Federal University of Rio Grande do Norte, Department of Informatics and Applied Mathematics, Natal, Brazil

[3]Universitat Politècnica de Catalunya, BarcelonaTech, Barcelona, Spain

[4]Vall dHebron University Hospital, Microbiology Department, Barcelona, Spain

[5]Aggeu Magalhães Research Center FIOCRUZ, Recife, Brazil

[6]Keizo Asami Laboratory of Imunopathology, Federal University of Pernambuco, Recife, Brazil

Corresponding Author:
Allisson Dantas Oliveira, MSc
Federal Rural University of Pernambuco
Department of Statistics and Informatics
Rua Dom Manoel de Medeiros, s/n, Dois Irmãos
Recife, 52171900
Brazil
Phone: 55 8133206491
Fax: 55 8133206491
Email: allissondantas@gmail.com

Abstract

Background: Malaria is a public health problem that affects remote areas worldwide. Climate change has contributed to the problem by allowing for the survival of Anopheles in previously uninhabited areas. As such, several groups have made developing news systems for the automated diagnosis of malaria a priority.

Objective: The objective of this study was to develop a new, automated, mobile device-based diagnostic system for malaria. The system uses Giemsa-stained peripheral blood samples combined with light microscopy to identify the Plasmodium falciparum species in the ring stage of development.

Methods: The system uses image processing and artificial intelligence techniques as well as a known face detection algorithm to identify Plasmodium parasites. The algorithm is based on integral image and haar-like features concepts, and makes use of weak classifiers with adaptive boosting learning. The search scope of the learning algorithm is reduced in the preprocessing step by removing the background around blood cells.

Results: As a proof of concept experiment, the tool was used on 555 malaria-positive and 777 malaria-negative previously-made slides. The accuracy of the system was, on average, 91%, meaning that for every 100 parasite-infected samples, 91 were identified correctly.

Conclusions: Accessibility barriers of low-resource countries can be addressed with low-cost diagnostic tools. Our system, developed for mobile devices (mobile phones and tablets), addresses this by enabling access to health centers in remote communities, and importantly, not depending on extensive malaria expertise or expensive diagnostic detection equipment.

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KEYWORDS

artificial intelligence; applied computing; automated diagnosis; malaria; mobile devices

Introduction

Malaria is a public health problem worldwide. A total of 214 million cases of malaria occurred globally in 2015 with 438,000 deaths [1]. In 2014, 97 countries reported the continuous transmission of malaria and the World Health Organization (WHO) estimates that around 3.2 billion people are at risk of becoming infected with this disease [1]. In most of the high-burden countries, weak healthcare systems contribute to slower than average declines in malaria incidences and high rates of mortality [1]. Therefore, early and accurate diagnosis of malaria is essential for effective disease management and surveillance. Indeed, misdiagnosis can result in significant morbidity and mortality. In addition, the correct diagnosis of patients with febrile illnesses may help to reduce the emergence and spread of drug resistance by reserving antimalarial treatments for those with a malaria diagnosis.

Malaria is currently diagnosed by microscopy with stained slides (thick blood films or blood smear) or by rapid diagnostic tests (RDTs) [2,3]. The thick blood film method of slide staining is the most common and inexpensive technique to diagnose malaria, whereas, the blood smear method is specifically used to identify the morphology and species of the *Plasmodium* parasite [4]. Today, it is essential that malaria diagnosis technicians are experienced in identifying species of *Plasmodium* using these techniques. For this reason, RDT methods are quite effective and widely used in some regions (ie, the Brazilian Amazon). However, RDT methods are expensive and not always effective in identifying samples with mixed species [3,5]. Furthermore, scientists are concerned about parasite resistance to antimalarial medicines and mosquito vector anopheles to insecticides [1]. Thus, a fast, in-place diagnosis system is essential to control malaria.

In recent decades, a number of researchers, including those from computing areas, have sought cost-effective solutions to assist health professionals in the control of epidemics and diseases. For example, Leal Neto et al (2014) developed a real-time diagnostic system for epidemiological events simulations [6]. Medical imaging has also been used successfully in the diagnosis of diseases. Kaewkamnerd and colleagues (2012) developed a 5-phase image analysis system to detect and classify malaria [7]. Techniques, such as hue-saturation-value (HSV) and adaptive threshold, have been used to extract image characteristics and automated systems of image capturing using a motor adapted to a microscope have been proposed [8]. In another study, Anggraini et al (2011) developed an application to successfully separate background of blood cells by solving image segmentation problems [9].

Here, we propose a low-cost, automated diagnostic system for malaria. Digital processing image techniques and a learning process based on artificial intelligence algorithms were combined to develop the system. Prior to app development, training and validation of the classifier were implemented on a personal computer in C++ language with Microsoft Windows 8.1. The minimum requirements for the app were that is used an Android operating system of 4.2 or higher and had a rear camera of at least 5 megapixels (MPs). Therefore, the Galaxy Tab 2 was used for testing. Taking advantage of this computing infrastructure, the system aims to aid public health officials in remote locations by trying to solve pending issues such as accessibility, cost, rapidness, and accuracy in malaria diagnosis.

Methods

The facial recognition method proposed by Viola and Jones is known as a heuristic method for the robust, fast, and accurate detection of faces in images [10]. Indeed, several studies have demonstrated the application of the technique [11-13]. The Viola and Jones' facial recognition method was used to develop a new method for the representation of images called integral image, which makes use of a simple and efficient classifier using an adaptive boosting learning algorithm [14]. It has also been used in the development of the cascade of classifiers method. This method uses a constant computational cost , which enables its use in real-time applications. The steps of the algorithm will be presented in the following sections.

Haar-Like Features

Historically, direct pixel manipulation has been a computationally complex problem [15]. As such, Viola and Jones [10] aimed to build a system that could be executed in constant time. They suggested an adaptation of the basic functions of haar described by Papageorgiou and colleagues [16], and began to use haar-like features added to the use of the integral image. Haar-like features are rectangles of white and dark regions. The features value is given by the difference between the sum of the intensities of the pixels of the light region (white) and the sum of pixel intensities in dark region (black) (equation a, Figure 1) where *f(w)* is a value of feature in the windows *w*, ΣP_{black} is the sum of pixels in the black region, and ΣP_{white} is the sum of pixels in the white region.

Four basic haar-like features are described to face-detection problems (Figure 2). Each resource-type of haar-like features indicates attendance or absence of features in the image, such as edge detection, texture, and others. The standard detector is used in 24 x 24 pixels, generating up to 160,000 rectangle features by subwindow [10,16].

Figure 1. Equations.

$$f(w) = \sum P_{black} - \sum P_{white} \quad \text{(a)}$$

$$ii(x,y) = \sum_{x^l \le x, y^l \le y} i(x^l, y^l) \quad \text{(b)}$$

$$ii(x,y) = f(x,y) + ii(x-1,y) + ii(x,y-1) - ii(x-1,y-1) \quad \text{(c)}$$

$$res(x,y) = R(0.299) + G(0.587) + B(0.114) \quad \text{(d)}$$

$$A \oplus B = \{z | (B)_z \subseteq A\} \quad \text{(e)}$$

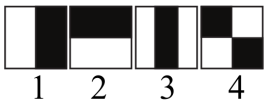
$$recall\ or\ sensitivity = \frac{TP}{TP + FN} \quad \text{(f)}$$

$$specificity = \frac{TN}{TN + FP} \quad \text{(g)}$$

$$PR = \frac{TP}{TP + FP} \quad \text{(h)}$$

$$accuracy = \frac{TP + TN}{TP + FP + FN + TN} \quad \text{(i)}$$

Figure 2. Haar-like features.



Integral Image

Integral image is an intermediate representation to quickly calculate the sum of values in a rectangular subset of a grid. The algorithm is used to calculate pixel function in real numbers *f(x,y)* (ie, to calculate pixel intensity along a rectangular region of the image). For a fast calculation of haar features' rectangles, Viola and Jones [10] proposed the use of integral image (equation b, Figure 1), where *ii(x,y)* is the integral image and *i(x,y)* is the original image. For each point *(x,y)* the value of the sum of all pixels higher and to the left is assigned, such that $x^1 \le x, y^1 \le y$.

The integral image can be obtained with a single pass over the image, using sum area value added in *(x,y)* (equation c, Figure 1). Once an integral image is computed, the evaluation of any area of the rectangle can be performed in constant time, using only four image references.

Adaptive Boost Algorithm

Viola and Jones [10] used the idea of weak classifiers, *h(x,f,p,θ)*. In that definition, there is a simple structure containing a subwindow *(x)* that consists of a feature *(f)*, threshold *(θ)*, and parity *(p)*.

The learning algorithm selects a unique feature that best separates the positive and negative examples. This feature was based on a machine learning meta-algorithm proposed by Freund and Schapire [14]. The outputs of the learning algorithm are called weak classifiers. These weak classifiers were combined with a weighted sum that represented the final result of the potential classifier. Its main feature was the distribution of weights in sets of examples and the distribution change over the course of the algorithm iterations [10].

Cascade of Classifiers

In the learning tasks, a high cost was given for evaluating the entire training set. While the reduction in the number of classifiers tended to improve the speed, the decrease of classifiers reduced the hit hat [15]. Viola and Jones proposed a solution to get a choice of good classifiers in a large set by creating decision trees called cascades of classifiers [10]. In the initial stage, the cascade of classifiers searched the simplest classifiers (generic) and rejected the greatest number of potential negative subwindows. The algorithm began with few features and, as it advanced, the number of cascade stages increased. With more stages the number of classifiers grew and the accuracy improved. In the detection of faces, the best cases are given between 15 to 25 stages [10].

Image Processing

Image processing techniques seek to improve the appearance or simplify an image, by correcting and/or eliminating noise that arose during image acquisition (equipment) or as a result of image degradations (lighting problems). Domains that are given to highlight on images are space, which refers to the plane of the image working directly on top of the pixels and frequency, which are changes in the images after Fourier transformation [17]. The interpretation of digital data is a computationally

complex task with a high computational cost [8]. The segmentation or partitioning of digital images into smaller parts is thus an essential task to assist the image interpretation process and images, in general, often contain distinct features that can complicate this process.

Differently-sized images, distorted shapes, lighting problems, and other characteristics contribute to image noise. Image noise, along with certain data contained in images can hamper the identification of features. For example, the image capture of car license plates occurs in uncontrolled environments (ie, lighting variations by virtue of time and weather conditions) [17]. The simplest and most widely used image segmentation technique is binarization which consists of classifying the pixels of a given image according to one or several thresholds. This technique is widely used to separate the background from the objects of interest. In global binarization, cutting a single threshold value is set for the entire image. This is advantageous because it improves processing time; however, image quality may be poor because of potential image noise. As such, global binarization is more suitable for controlled environments. On the other hand, local binarization allows for different cutoff points to different regions of the image. A disadvantage of this technique is the high processing time [14,18].

Experimental Approach

We developed a mobile device-based automated system to detect malaria. The algorithm specifically identifies *Plasmodium falciparum* in the trophozoite ring stage. Preprocessing steps were used to improve the quality of the microscopy images (eg, Otsu [19]), and Gaussian filters [20] and mathematical morphology techniques [14] were used for training and classification. With respect to image acquisition, preprocessing, training, and validation were performed on a personal computer (Intel Core i3-3217U 1.8 GHz 4096MB RAM) prior to the development of the mobile app (Android 4.2 or higher). The flow of activities in the experimental model is illustrated in Figure 3.

Figure 3. Flowchart of the experimental model.

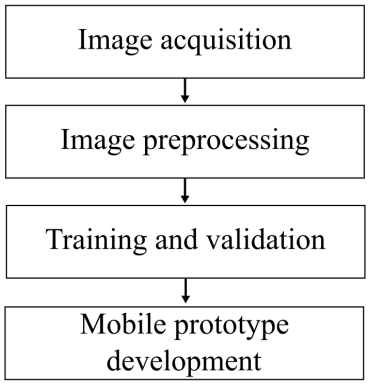


Image Acquisition

An image acquisition step was necessary in the development of the experimental model. The Microbiology Department (Drassanes Unit) of Vall Hebron Hospital, Barcelona, Spain and the microbiology lab of the Research Center Aggeu Magalhães(FIOCRUZ) Recife, Brazil have a collection of about 500 slides from patients diagnosed with malaria. All the images obtained were classified by experimental parasitologists. This collection was used to perform the image acquisition for the diagnosis algorithm.

Malaria parasites require magnification of at least 1000 times for their identification in blood smears [1]. A light microscopy was used along with the Logitech c270 (webcam), the Samsung Galaxy Tab 2 (mobile phone), and the Sony DSC H1 (semi-professional camera). Polyvinyl chloride (PVC), low-cost support pieces (less than US $1) were designed to attach the devices to the light microscopes and to the 3D printer. The image acquisition stage is illustrated in Figure 4.

Figure 4. Polyvinyl chloride (PVC) was used as support for the tablet (left) and mobile phone (right).

Image Preprocessing

In the preprocessing step, some improvements in the images were made to limit the scope or search space for the classification algorithm. The preprocessing step is shown in Figure 5. The original image was given in the red, green, blue (RGB) color model. This model was used because it is the most popular and simple to implement. In addition, since RGB is used in devices such as monitors, video cameras, and mobile phones, conversions to other color models was not required [8]. For this step, the original image was acquired through the blood smear method [1].

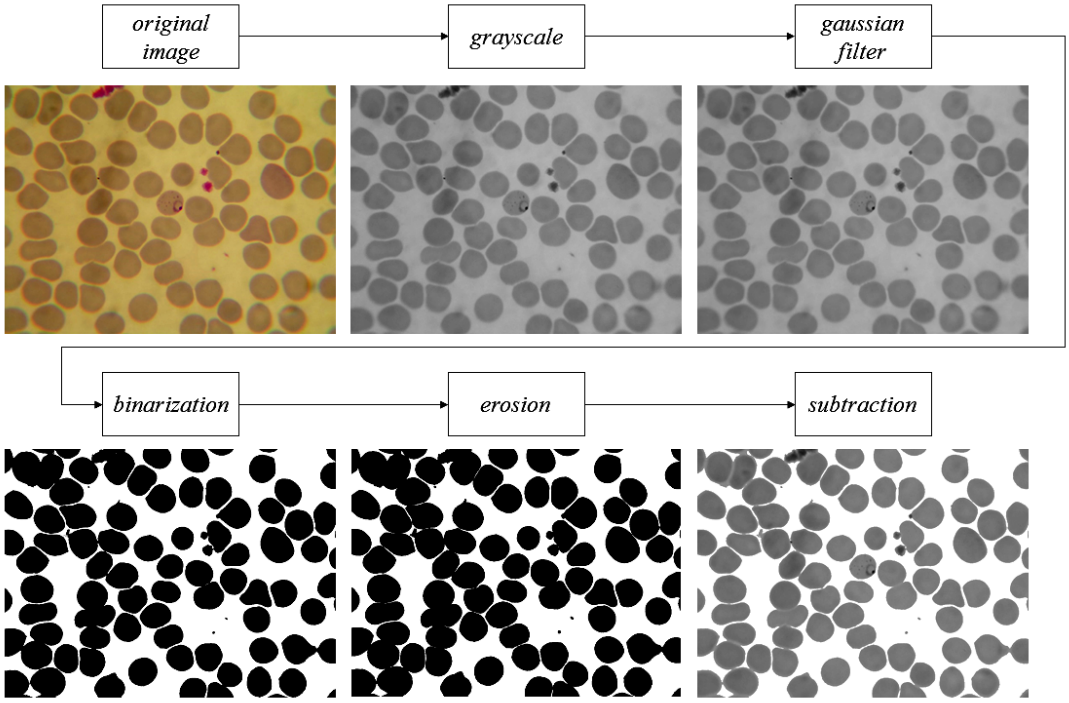
The objective of this preprocessing step was to reduce the search scope, such as separate blood smears of the background. In this study, we did not use the entire RGB color space model, since performing segmentation operations on images with several layers of colors can be quite expensive computationally [8]. The original image was thus converted to grayscale with only a single color space (equation d, Figure) where *res (x,y)* is the image in grayscale. After converting the image, the grayscale was replaced by a single color space, with black of lesser intensity and white of greater intensity [9].

A Gaussian filter was then used which gave the convolution, where, for each item on the input array, a Gaussian kernel was applied. The output is the filter operation based in a Gaussian function [14,19]. The kernel size was fixed to 7 x 7, so that the result was a smoother image. This operation was justified for a better bottom extraction [14], and with the reduction of some details and elements of the images, the edges of the red blood cells became more defined. Thresholding separated the grayscale in a given image such that the image was transformed into two grayscales groups: 0 (100% black) and 255 (100% white). For this process, it was necessary to set a cutoff or threshold to separate the two groups. The definition of this cutoff point was very important, because the images had different characteristics (eg, lighting and focus).

The Otsu thresholding technique [19] was chosen because it is widely used in the literature and the cutoff feature has an optimal, automatic threshold. The OTSU technique uses a nonparametric approach (not estimating the parameters of the model) and an unsupervised stop to find the automatic threshold in a given image [21]. The method contains the background and foreground pixel classes, represented by C1 and C2, respectively [19]. After the image was smoothed by the Gausssian filter, it was transformed into a binary image containing only foreground (blood cells) and background (rest of the image). With respect to malaria detection, the background is not important because most parasites lie within the cells of the prepared blood smears [5]. Morphological operations may be applied to images to enhance the geometric structures on a set of pixels. Erosion is a morphological technique that seeks to combine two sets by subtracting the vectors for the intersection sets of A and B (equation e, Figure 1).

The preprocessing transformation steps were necessary for locating the RBCs and restricting the search space of the algorithm. After the erosion, a subtraction was performed with the image converted to grayscale and the background was removed. The final result is shown in Figure 5.

Figure 5. Image preprocessing steps.



Training and Validation

The objective of the training and validation steps was to find a good classifier to recognize the parasite *Plasmodium falciparum* in the trophozoite (ring stage) in a given image. The training and validation of classifiers was performed according to the method by Viola and Jones [10] using an Intel Core i3-3217U (1.8 GHz 4096MB) computer.

For all the training sets, the following parameters were used: (1) the amount of memory was 1024, (2) a minimum hit rate of 0.99500, (3) a maximum false alarm rate of 0.400000, (4) basic, haar-like features mode [10,22], (5) a subwindow weight of 24, and (6) a subwindow height of 24.

Every image was classified as positive or negative, where positive referred to images infected with the *Plasmodium falciparum parasites* (trophozoite ring stage), whereas negative referred to white blood cells and empty RBCs (false positive). After classifying the images, the adaptive boosting algorithm was used to select the best features according to the stage of the cascade of classifiers [10]. The result of the training was a degenerative decisions tree with two positive and negative classes.

Mobile App Development

Currently, the major developers of operating systems for mobile devices are Google Android, Apple IOS, and Microsoft Windows Phone [23-26]. Globally, Android is the most popular mobile operating system with about 1 billion users connected on various devices (tablets, mobile phones, televisions, etc) [24]. Android-based apps are mostly developed in Java [27]; however, apps can be also created in C/C++ using the Native Development Kit (NDK) [24].

We developed an automated, mobile device-based tool (Android) for the rapid and accurate diagnosis of malaria. The prototype development flow (pseudocode) is shown in Table 1.

Table 1. Prototype development flow.

Algorithm
1: initialize camera
2: set the camera resolution to 640 x 480 pixels
3: **While** true **do**
4: view image in camera
5: perform to image scanning through windows 24 x 24 pixels (multi-scale)
6: **if** *find the object of interests* **then**
7: mark the object and count
8: **end if**
9: **else** *keep looking*
10: **end while**
11: **if***press the button return***then**
12: close the application and release the camera
13: **End if**

Detection was performed by the mobile camera operating at a resolution of 640 x 480 pixels, with an average rate of 5 frames per second (FPS). Factors such as distance, lighting, and training set influenced the detection rate. While the camera is fixed, sight (focus) is adjusted manually on a light microscope. Parasites were detected on a frame-by-frame basis [10].

A second app was also developed that detects malaria in previously-acquired images. While the image analysis procedure is the same, the second app has a button that can upload an image rather than acquiring it with the device camera.

Results

A set of experiments was designed to evaluate and quantify the accuracy of the developed tool in diagnosing malaria. The evaluation was binary, using positive (infected with *Plasmodium*-type parasites) and negative (not infected) classes. The acronyms used in the evaluation were positive sample (P), negative sample (N), parasites correctly detected as positive (TP), correctly identified as negative objects (TN), objects that are not parasites of the *Plasmodium sp* (FP), and positive parasites not detected by the classifier (FN).

In the field of artificial intelligence, metrics to evaluate performance are given. Here, the metrics of recall or sensitivity, specificity, precision rate (PR), and accuracy were used to evaluate the classifiers [28,29]. Recall or sensitivity measured the percentage of positive samples correctly classified as positive samples (equation f, Figure 1). Specificity measured the percentage of correctly identified negative samples out of the total number of negative samples (equation g, Figure 1). PR was the probability that a retrieved sample was relevant (equation h, Figure), whereas accuracy was the proximity degree between the value obtained and the true value (equation i, Figure 1).

Our system was tested using samples from the Microbiology Department (Parasitology Drassanes Unit) of Vall Hebron Hospital, Barcelona, Spain and the (microbiology lab) of Research Center Aggeu Magalhães (FIOCRUZ) Recife, Brazil. For these samples, the images were acquired using the mobile devices (Figure 4). The rest of the images were obtained from Wellcome Images [30,31].

As a preliminary experiment, the classifier was given 555 positive and 777 negative samples. A 10-fold cross-validation procedure was used for training and testing [10] using the adaptive boost algorithm. The results are shown in Tables 2 and 3.

Table 2. The 10-fold, cross-validation procedure on 10-, 15-, and 20-stage cascades.

Cascade	Iteration (K)	Specificity	Recall or sensitivity	Accuracy	PR[a]
10-stage					
	1	0.7075	0.7272	0.7096	0.2272
	2	0.9331	0.6428	0.9019	0.5373
	3	0.6414	0.8070	0.6596	0.2169
	4	0.8838	0.6545	0.8596	0.4000
	5	0.8731	0.7090	0.8557	0.3979
	6	0.8666	0.8727	0.8673	0.4363
	7	0.3383	0.6785	0.375	0.1101
	8	0.1626	0.8983	0.2461	0.1207
	9	0.6206	0.7857	0.6384	0.2000
	10	0.7960	0.8437	0.8019	0.3673
15-stage					
	1	0.9548	0.5090	0.9076	0.5714
	2	0.9892	0.4000	0.9269	0.8148
	3	0.9137	0.6964	0.8903	0.4936
	4	0.9634	0.7636	0.9423	0.7118
	5	0.9590	0.7142	0.9326	0.6779
	6	0.9482	0.9107	0.9442	0.6800
	7	0.8134	0.7627	0.8076	0.3435
	8	0.8599	0.6607	0.8384	0.3627
	9	0.8663	0.7500	0.8538	0.4038
	10	0.9234	0.7301	0.9000	0.5679
20-stage					
	1	0.9913	0.1636	0.9038	0.6923
	2	0.9956	0.1818	0.9096	0.8333
	3	0.9698	0.4464	0.9134	0.6410
	4	0.9655	0.7500	0.9423	0.7241
	5	0.9698	0.8035	0.9519	0.7627
	6	0.9590	0.8214	0.9442	0.7076
	7	0.9092	0.6491	0.8807	0.4683
	8	0.9652	0.4576	0.9076	0.6279
	9	0.9202	0.7500	0.9019	0.5316
	10	0.9650	0.4677	0.9057	0.6444

[a]PR: precision rate.

Table 3. Metric results reported as means (SDs).

Metric	Stage	Mean (SD)
Recall or sensitivity[a]		
	10	0.7619851 (0.092387416)
	15	0.6897741 (0.142576715)
	20	0.5491375 (0.244642849)
Specificity[b]		
	10	0.6823637 (0.2541448)
	15	0.9191804 (0.0558795)
	20	0.9611227 (0.0272376)
Average accuracy		
	10	0.6915384 (0.2224334)
	15	0.8938034 (0.0497291)
	20	0.9161538 (0.0225766)
PR[c]		
	10	0.3014110 (0.1450627)
	15	0.5627748 (0.1602032)
	20	0.6633560 (0.1068479)

[a]False positive rate.

[b]False positive rate.

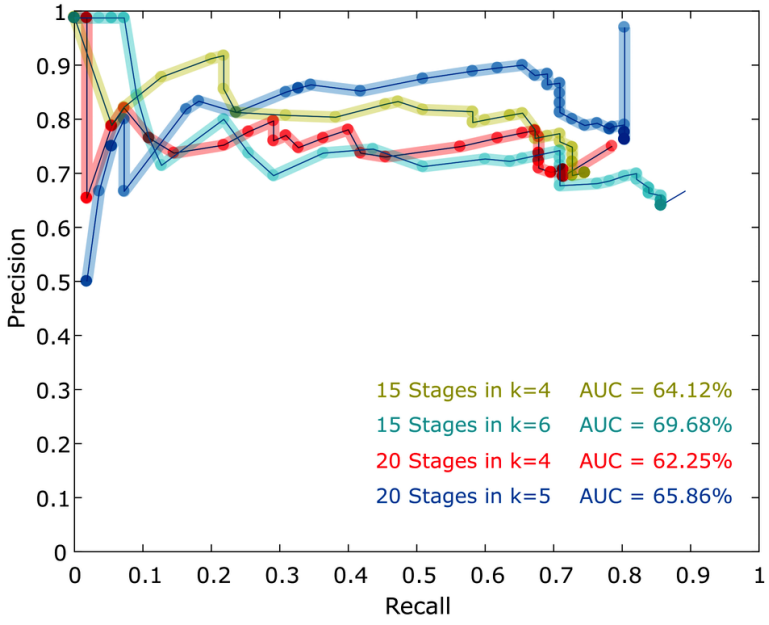
[c]PR: precision rate.

Discussion

Principal Findings

We developed a low-cost, automated, mobile device-based tool to diagnose malaria using image segmentation and artificial intelligence techniques. Based on the preliminary results, the classifier algorithm performed better using the 20-stage cascade with average specificity and accuracy values of 96% and 91%, respectively. Recall, however, was better using the 10-stage cascade, even though there were a high number of false positives that decreased the precision of the algorithm. Precision-recall curves were generated for the four best iterations (K) using the cross-validation method (Figure 6). The best area under the precision-recall curve was when recall and precision assumed a value of 1. After analyzing the curves, it was estimated that the 15-stage cascade in iteration 6 yielded the best result with respect to area under the curve (70%).

Figure 6. Precision-recall curve of the four iterations of the cross-validation method.



Future Work

Currently, the highest level of accuracy was 91%. Based on these findings, the tool is feasible [12,13] and with new sets of positive images, higher rankings with respect to specificity and sensitivity are possible. In the future, variations and adaptations to the Viola and Jones [10] method may be enable detection of other species and stages of malaria development. In addition, new training algorithms such as neural networks [32], support vector machines [33], and even other image processing techniques [8,20] may be explored.

Conclusions

The development of a low-cost, rapid, and accurate diagnosis tools for mobile phones and tablets that can be used in health centers in remote communities without the need for specific expertise could help break the accessibility barriers of low-resource countries. The tool that we developed can achieve this by virtue of its accessibility and on the spot, real-time diagnostic potential that may facilitate immediate treatment.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Screenshot of the Malaria System app beta version.

[PDF File (Adobe PDF File), 319KB - resprot_v6i4e70_app1.pdf]

Multimedia Appendix 2

Video demo of the Malaria System.

[MOV File, 5MB - resprot_v6i4e70_app2.mov]

References

1. World Health Organization. World Malaria Report 2015. 2015 Dec. URL: http://www.who.int/malaria/publications/world-malaria-report-2015/report/en/ [accessed 2016-10-01] [WebCite Cache ID 6kwew4pPq]
2. World Health Organization. Management of Severe Malaria: A Practical Handbook, Third Edition. 2012. URL: http://apps.who.int/iris/bitstream/10665/79317/1/9789241548526_eng.pdf?ua=1 [WebCite Cache ID 6png8iL9Z]
3. de Oliveira MR, de Castro Gomes A, Toscano CM. Cost effectiveness of OptiMal® rapid diagnostic test for malaria in remote areas of the Amazon Region, Brazil. Malar J 2010 Oct 11;9:277 [FREE Full text] [doi: 10.1186/1475-2875-9-277] [Medline: 20937094]
4. World Health Organization. Basic Malaria Microscopy: Part 1 Learner's Guide. Geneva: World Health Organization; 1991.
5. World Health Organization. New Perspectives: Malaria Diagnosis. URL: http://www.who.int/tdr/publications/documents/malaria-diagnosis.pdf [accessed 2016-09-19] [WebCite Cache ID 6ke1kzDx4]
6. Leal Neto OB, Albuquerque CM, Albuquerque JO, Barbosa CS. The schisto track: a system for gathering and monitoring epidemiological surveys by connecting geographical information systems in real time. JMIR Mhealth Uhealth 2014 Mar 10;2(1):e10 [FREE Full text] [doi: 10.2196/mhealth.2859] [Medline: 25099881]
7. Kaewkamnerd S, Uthaipibull C, Intarapanich A, Pannarut M, Chaotheing S, Tongsima S. An automatic device for detection and classification of malaria parasite species in thick blood film. BMC Bioinformatics 2012;13 Suppl 17:S18 [FREE Full text] [doi: 10.1186/1471-2105-13-S17-S18] [Medline: 23281600]
8. Gonzalez RC, Woods RS. Digital Image Processing. Upper Saddle River, NJ: Pearson/Prentice Hall; 2008.
9. Anggraini D, Nugroho A, Pratama C, Rozi I, Iskandar A, Hartono R. Automated status identification of microscopic images obtained from malaria thin blood smears. 2011 Presented at: 2011 International Conference on Electrical Engineering and Informatics (ICEEI); 2011 July 17-19; Bandung, Indonesia p. 6. [doi: 10.1109/ICEEI.2011.6021762]
10. Viola P, Jones MJ. Robust real-time face detection. Int J Comput Vision 2004 May;57(2):137-154. [doi: 10.1023/B:VISI.0000013087.49260.fb]
11. Firmo AC, Oliveira AD, Viegas J, Albuquerque J. Schistosystem - inteligencia artificial para diagnostico automatico por imagens. Porto Alegre, Brazil: IADIS; 2013 Presented at: Atas da Conferencia IADIS Ibero-Americana Computacao Aplicada; 2013 Dec 10-11; Lisbon, Portugal p. 87.

12. de Oliveira AD, Cabral G, López D, Firmo C, Serrat ZF, Albuquerque JO. A proposal for automatic diagnosis of malaria: extended abstract. 2013 Presented at: Proceedings of the 22nd International Conference on World Wide Web (WWW '13 Companion); 2013 May 13-17; Rio de Janeiro, Brazil p. 681-682. [doi: 10.1145/2487788.2488022]
13. de Oliveira AD, Arruda ME, Prat JG, Codina DL, Serrat FZ, Albuquerque JO. Malaria system: a new tool for automatic diagnosis of malaria in mobile devices. : JMIR; 2014 Presented at: 7th World Congress Medicine 2.0; 2014 Oct 9-10; Malaga, Spain p. 1 URL: http://www.medicine20congress.com/ocs/index.php/med/med2014b/paper/view/2487
14. Freund Y, Schapire RE. Journal of JSAI. 1999. A short introduction to boosting URL: http://www.yorku.ca/gisweb/eats4400/boost.pdf [accessed 2016-09-20] [WebCite Cache ID 6kfHYe9Si]
15. Gonzalez RC, Woods RE. Processamento de Imagens Digitais. São Paulo, Brazil: Edgard Blucher; 2000:85-212.
16. Papageorgiou C, Oren M, Poggio T. A general framework for object detection. 1998 Presented at: IEEE International Conference on Computer Vision; 1998 Jan 7; Bombay, India. [doi: 10.1109/ICCV.1998.710772]
17. Pedrini H, Schwartz W. Análise de Imagens Digitais: Princípios, Algoritmos e Aplicações. São Paulo, Brazil: Thomson Learning; 2008:506.
18. Bradski G, Kaehler A. Learning OpenCV: Computer Vision With the OpenCV Library. Sebastopol, CA: O'Reilly; 2008.
19. Otsu N. A threshold selection method from gray-level histograms. IEEE Trans Syst Man Cybern 1979 Jan;9(1):62-66. [doi: 10.1109/TSMC.1979.4310076]
20. Szeliski R. Computer Vision: Algorithms and Applications (Texts in Computer Science) 2011th Edition. Springer London: Springer; 2011.
21. Laganière R. OpenCV 2 Computer Vision Application Programming Cookbook. Ottawa: Packt Publishing Limited; 2011.
22. Lienhart R, Maydt J. An extended set of haar-like features for rapid object detection. Piscataway, New Jersey: IEEE; 2002 Presented at: ICIP: 2002 International Conference on Image Processing; 2002 Sept 22-25; Rochester.
23. Android Developer. URL: https://developer.android.com/index.html [accessed 2016-09-20] [WebCite Cache ID 6kfIHUOUN]
24. Mednieks Z, Dornin L, Meike G, Nakamura M. Programming Android: Java Programming for the New Generation of Mobile Devices. California: O'Reilly Media; 2012.
25. IOS Developer. URL: https://developer.apple.com/ [accessed 2016-09-20] [WebCite Cache ID 6kfItR0Ek]
26. Microsoft Windows Phone. URL: https://www.microsoft.com/windows/phones [accessed 2016-09-20] [WebCite Cache ID 6kfIzUwOV]
27. Schildt H, Skrien D. Programação com Java: Uma Introdução Abrangente. São Paulo, Brazil: Bookman Editora; 2013.
28. Olson DL, Delen D. Advanced Data Mining Techniques. Berlin: Springer; 2008.
29. Araujo GM. Algoritmo Para Reconhecimento de Características Faciais Baseado em Filtros de Correlação. Master's thesis. PPEE - UFRJ. 2010. URL: http://www02.smt.ufrj.br/~eduardo/teses/gabriel-matos-mestrado.pdf [accessed 2016-09-20] [WebCite Cache ID 6kfJOJJf7]
30. Center for Disease Control Prevention. Public Health Image Library (PHIL). URL: http://phil.cdc.gov/phil/default.asp [accessed 2016-09-20] [WebCite Cache ID 6kfJVUdyl]
31. Wellcome Images. URL: https://wellcomeimages.org/ [accessed 2016-09-20] [WebCite Cache ID 6kfJaKLQJ]
32. Haykin SS. Redes Neurais: Princípios e Práticas. São Paulo, Brazil: Bookman Companhia Ed; 2001.
33. Duda RO, Hart PW, Stork DG. Pattern Classification. New York: John Wiley & Sons; 2001.

Abbreviations

FPR: false positives rate
PR: precision rate
RBCs: red blood cells
RCT: randomized controlled trial
RDT: rapid diagnostic tests
RGB: red, green, blue
ROC: receiver operating characteristic
TPR: true positives rate

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Original Paper

Evaluation of a Mindfulness-Based Mobile App Aimed at Promoting Awareness of Weight-Related Behaviors in Adolescents: A Pilot Study

Tami Turner[1], PhD; Melanie Hingle[1], RD, MPH, PhD

Department of Nutritional Sciences, The University of Arizona, Tucson, AZ, United States

Corresponding Author:
Tami Turner, PhD
Department of Nutritional Sciences
The University of Arizona
1177 E 4th St, Shantz Bldg, Room 328
Tucson, AZ,
United States
Phone: 1 520 626 7112
Fax: 1 520 626 3446
Email: tamiturner@email.arizona.edu

Abstract

Background: Mindfulness-based interventions are reported to be highly acceptable and have positive effects on youth, yet most are clinic- or school-based aimed at emotional regulation or academic performance. To provide flexible program delivery, we developed and tested a standalone mindfulness-based app aimed at improving weight-related behaviors (eg, diet, physical activity, sleep) in adolescents.

Objective: Our objective was to assess the feasibility, acceptability, and utility of a mindfulness-based mobile app.

Methods: In a single-arm pilot study, 15 adolescents (14-18 years) were prompted to access the app once a day, every day for 6 weeks. Outcomes were measured by in-app and poststudy surveys, and descriptive statistical analyses were performed. Time within a mindfulness state was self-reported during weekly timed practices.

Results: The app was rated highly for content and encouraging the practice of activities to promote mindfulness states. Teens reported increased awareness of eating behaviors and high adherence, particularly during physically active practices. Average self-reported time spent in a mindfulness state increased 2.5 times by week 6 (78 [SD 17] seconds) compared to week 1 (31 [SD 21] seconds).

Conclusions: The high acceptability and utility ratings of the app, increases in reported time in mindfulness states, and high frequency of participation, including mindful eating and physical activity, suggest the mindfulness-based mobile app has the potential to improve awareness of weight-related behaviors.

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KEYWORDS

mindfulness; adolescent; mHealth; diet; physical activity; app

Introduction

The psychological state of mindfulness facilitates present moment awareness, objective self-observation, and attention to the environment without judgement [1-3]. Mindfulness may promote greater self-regulation, as is required for successful weight management, because intermittent self-monitoring of goals produces less effective self-regulation than does regular attention to one's present behavior [4]. In adults, mindfulness-based interventions related to eating have increased awareness of satiety; feelings and thoughts about food and the food environment [5-8]; and reduced weight, body mass index (BMI), and caloric and fat intake [5,7]. Mindfulness-based interventions have decreased blood pressure in adolescents with increased risk of cardiovascular disease [9], improved body satisfaction and reduced disordered eating thoughts in fifth grade girls [10], improved sleep in youth with history of substance abuse [11], and increased physical activity and improved dietary habits in overweight and obese teens [12]. However, the majority of mindfulness-based interventions for youth have been school-

or clinic-based programs aimed at improving emotional regulation and academic performance [13,14]. Little research has investigated the effect of mindfulness on weight-related behaviors in youth.

Acceptability of mindfulness interventions in youth is high [14,15]; however, time commitment associated with attending face-to-face programs is a frequently cited reason for nonparticipation in adolescents [16]. Research also confirms mobile health (mHealth) interventions are feasible and acceptable approaches in the prevention and treatment of pediatric obesity [17], and teens report a preference for virtual mindfulness-based health promotion programs [18]. We are unaware of mHealth programs focused on mindfulness to increase awareness of weight-related behaviors in adolescents. The objective of this study was to evaluate the acceptability, feasibility, and utility of a mindfulness-based intervention delivered via mobile app in teens aged 14 to 18 years.

Methods

App Development

A series of videos was created using animation software (GoAnimate.com) and integrated into an established mobile- and cloud-based app platform developed by our industry partners at Vignet, Inc, thereby creating the b@Ease Mindfulness App. The mobile app and its cloud server are secured and compliant with the Health Insurance Portability and Accountability Act and the Health Information Technology for Economic and Clinical Health Act to protect participant privacy and confidentiality.

Elements of face-to-face mindfulness-based programs were integrated into the videos, including self-observation skill-building, increasing awareness of hunger/satiety cues and the sensory aspects of eating, and purposefully paying attention to physical movement of the body. Regardless of the method used to focus attention (eg, breath), intervention content emphasized achieving and remaining in a mindful state. Videos used fictional storytelling and analogy to communicate, presented techniques to evoke a state of mindfulness, encouraged participation during guided practices, and challenged teens to integrate mindfulness into life as independent practice. Videos range from 2 to 15 minutes (mean 7.5 [SD 2.8] minutes).

Guided practices occurred on 37 days (88% of videos), with mindful eating and physical movement practices presented on 18 days (43% of videos). Textbox 1 summarizes video topics, techniques, and storytelling examples.

Textbox 1. Content of videos within the b@Ease Mindfulness App.

Topics:

- General mindfulness
- Sleep
- Mindful eating
- Physical activity
- Stress
- Social/relationships

Techniques to initiate mindfulness states:

- Meditation
- Guided imagery
- Mindful eating
- Sensory (eg, auditory, visual)
- Body scans (eg, hunger, emotions)
- Progressive muscle relaxation
- Seated and standing stretching and movement
- Yoga and stationary standing postures (eg, balancing)
- Mindful walking and martial arts forms

Story examples:

- Hippo with insomnia learns breath meditation
- Talking body parts argue over who's really hungry; mindful eating instruction follows
- Alien dies from mindless eating accident; how to prevent being a victim with mindful eating
- Boyfriend assumes mate is cheating but learns thoughts are not necessarily true; a sensory guided practice follows
- Frankenstein's monster complains about achy body and learns mindful stretching
- Boy catastrophizing over a future public speaking event learns mindful walking

Recruitment and Enrollment

Adolescents were recruited from Tucson, Arizona, via flyers posted at community organizations and online (eg, Facebook). Eligibility criteria included teens aged 14 to 18 years willing to participate and use personal mobile devices to use the study app and able to read and speak fluent English. Exclusion criteria included psychological pathologies (depression, anxiety disorders, posttraumatic stress disorder, schizophrenia, bipolar disorder), conditions that affect attention or mood (attention deficit hyperactivity disorder, medications), trauma, epilepsy, and disordered eating behaviors. The Patient Health Questionnaire (PHQ-4) [19] was used to screen for anxiety and depression, the Eating Attitudes Test (EAT-26) [20] for eating disorders, and participants were asked if they had experienced or were diagnosed with or seen by a professional for the remaining conditions. While body weight status (eg, obesity) was not included as an eligibility criterion, it was collected to understand more about the teens who chose to participate. Interested teens provided parental-permitted assent or consent and were screened using an online, encrypted, password-protected survey distributed via Qualtrics survey software sent as a link to the participant's email. Participants received up to $50 for completing study procedures. The Institutional Review Board of The University of Arizona, Tucson, Arizona, approved the study.

Intervention

At baseline, participants self-reported height, weight, gender, race, and ethnicity. Participants were asked if they had previously heard of mindfulness and whether they had participated in yoga, meditation, guided imagery, body scans, internal martial arts (eg, Ba Gua, Tai Chi), or other mind-body techniques. Participants downloaded the app onto their mobile devices, registered the app, and were asked to access the app every day for 6 weeks. To prevent the study from extending beyond 6 weeks, participants were only able to view one video per day and unable to skip or return to previous videos and the corresponding in-app surveys. Daily prompts encouraged video viewing each morning (streamed from YouTube), and a postvideo in-app survey requested self-reported adherence to video viewing and acceptability (based on a 5-point Likert scale). If the survey remained incomplete by 8 PM, an additional notification was sent. In-app surveys also assessed whether participants engaged in independent practices at least weekly on 8 separate occasions. If the participant indicated they tried the independent practice, a follow-up question asked if it was helpful or enjoyable. The poststudy survey included questions on facilitators and barriers to performing mindful eating and physical activity, likelihood of adopting mindfulness techniques, perceived utility of the content within the app, and app functionality ratings.

Once a week, a scheduled video led participants through a guided timed practice to estimate how long they were able to remain in a mindfulness state. Following the video, participants reported the number of times they were *not* in a mindful state during the practice (ie, when they caught themselves thinking of something else and had to start over). Durations were computed as the sum of the intervals of time within a mindfulness state during the practice (eg, if during a 3-minute timed practice they started over twice, 3 periods resulted, and 1-minute average time was computed). Timed sessions progressively increased from 3 to 15 minutes over the study duration.

Acceptability and utility were defined as interest and enjoyment, perceived usefulness, perceived influence on behavior and/or affect, likelihood of adoption of mindfulness techniques, and app functionality. Feasibility was defined as the capacity of the app to engage participants measured by adherence to recommended app use and participant-reported facilitators and barriers to mindful eating and physical activity practices. Data collected within the app included video ratings (based on a 5-point Likert scale) and frequency of adherence to and usefulness of several guided and independent practices (eg, "Did you try it?" and "Did you like it?") (see Multimedia Appendix 1). The poststudy survey (Multimedia Appendix 2) asked participants to assign Likert scale ratings or A to F "grades" to indicate liking of content and practices; perceived influence of the app and facilitators/barriers to mindfulness related to eating, physical activity, and sleep-related activities; likelihood of adopting mindfulness as a practice; ease of use; and technical ratings of the app. Free text comments for suggestions for improvement of the app were also solicited as part of the poststudy survey. Survey questions of facilitators and barriers to participating in mindful eating and physical activity were only asked if participants stated they participated in the activity at least sometimes or more frequently. Furthermore, participants were able to submit in-app comments or questions if desired (Multimedia Appendix 3).

Statistical Analysis

Analyses were conducted using Excel 2010 (Microsoft Corp), Qualtrics survey software (Qualtrics), and SPSS version 23.0 (IBM Corp). Descriptive analyses provided central tendency and dispersion for characteristics of participants, data collected within the app, and from the poststudy survey. Fisher exact test was used to determine whether baseline participant characteristics differed between teens completing the poststudy survey and teens who did not. Statistical significance was defined at the 95% confidence level ($P<.05$, 2-tailed). Changes in self-reported time spent in a mindfulness state for participants who viewed the guided practice videos are summarized.

Results

Participant Characteristics

Of the 95 interested respondents, 66 provided their email address to receive a secure link to complete the screening survey. The majority of ineligible participants (43/66, 65%) indicated they may have a mental health condition or received scores on the PHQ-4 suggesting they may have depression or anxiety. A smaller number of teens (12/66, 18%) were ineligible due to scores on the EAT-26 suggesting they were affected by disordered eating behaviors.

Of the 66 participants screened, 20 met eligibility criteria and were enrolled (Figure 1). A total of 5 participants did not complete app registration or experienced device difficulties

preventing app use. A total of 15 teens completed baseline surveys and answered surveys within the app, and 9 completed the poststudy questionnaire. Characteristics of participants who registered for the app are shown in Table 1. A high proportion of participants were Hispanic, 20% were overweight or obese, and one-third had heard of mindfulness. Of the 15 teens, 9 indicated they had performed activities such as yoga, which may or may not have been mindfully executed, indicating some may have had prior experience.

All 15 participants provided data within the app including rating videos and answering questions related to independent practices (eg, "Did you try the technique?" and "Did it help you?"), and 9 participants completed the poststudy survey and rated content, techniques, frequency of mindfulness practice, utility of the app to promote mindfulness in various ways, and likelihood of adoption. There were no differences between teens who completed the poststudy survey and teens who did not when comparing gender (P=.12), race (white vs mixed or nonwhite, P=.53), Hispanic versus non-Hispanic (P=.13), age group (14-16 years vs 17-18 years, P=.98), familiarity with mindfulness (P=.61), any previous practices that may have included mindfulness (P=.58), or weight status (normal vs overweight or obese, P=.77).

Table 1. Characteristics of the participants registered for the b@Ease Mindfulness App (n=15).

Variable	User testing
Age, years, mean (SD)	16.5 (1.4)
Gender, n (%)	
Male	8 (53)
Female	7 (47)
Race/ethnicity[a] , n (%)	
Hispanic/Latino	9 (60)
Not Hispanic/Latino	6 (40)
African American	1 (7)
Asian	2 (13)
Native American	1 (7)
White	14 (93)
Unknown/refuse	2 (13)
BMI[b] (kg/m^2), mean (SD)	23.1 (4.3)
BMI percentile, mean (SD)	62.1 (26.1)
Weight, n (%)	
Normal[c]	12 (80)
Overweight/obese[c]	3 (20)
Heard of mindfulness, n (%)	5 (33)
Possible prior mind-body practices[d], n (%)	9 (60)

[a]All applicable races were allowed.

[b]BMI: body mass index.

[c]Based upon BMI percentile.

[d]Choices included yoga (n=7), meditation (n=4), guided imagery (n=0), body scans (n=0), internal martials arts (eg, Chi Gong, n=1), or other mind-body techniques (n=1).

Acceptability and Utility

Participants highly rated the videos (in-app survey mean 3.8 [SD 0.3] out of 5). The techniques, guided practices, and the utility of the app were rated highly in the poststudy survey (see Figure 2), especially videos related to physical movement, mindful eating, and sensory practices. Participants reported increased awareness of eating behaviors in poststudy surveys; comments included, "I was surprised at how much better my food tasted and how I ate less than I normally would have." Physical activity practices were also highly rated, especially when presented as a way to appreciate and reward the body. The lowest rated videos were timed practices exceeding 8 minutes. Suggestions for improvement included shortening timed practices, allowing users to return to earlier videos, and allowing customization of app prompts to coincide with meal times. There were no reported adverse effects. Participants reported the app to be very helpful and enjoyable and reported feeling more relaxed, focused, and peaceful. Furthermore, participants stated the videos explained mindfulness as "so simple and understandable," and users reported a high likelihood of adopting mindfulness practices. Overall, the intervention

content was given an average grade of B while the functionality of the app received a B+ (scale of A-D, F).

Figure 1. Flow of participants in the b@Ease Mindfulness App for Teens study.

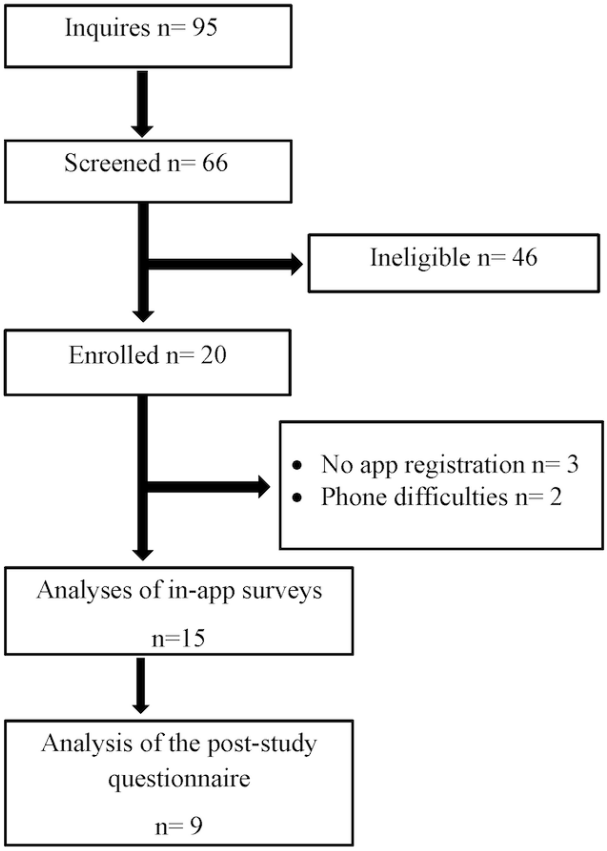
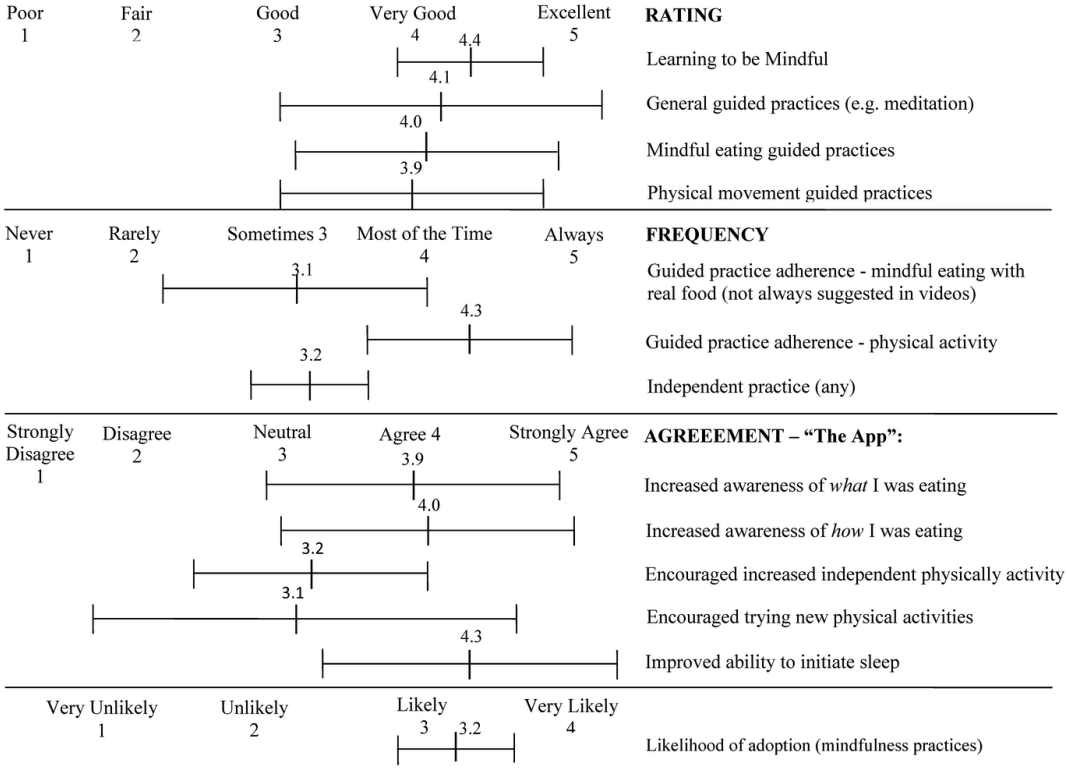


Figure 2. Poststudy survey results of the b@Ease Mindfulness App for Teens study (n=9, all data are mean [SD]).



Feasibility

Using in-app survey responses as a proxy to measure adherence, the percentage of daily responses averaged 55% (all participants) to 73% (excluding 4 teens who stopped participating within the first few days). Thus, participants received an average of 23 (SD 17) days to 31 (SD 15) days of intervention time representing 3 to 4 hours of total viewing. All but one participant reported practicing with real food from some to every time during the guided practices focused on mindful eating; facilitators were timing of video (eg, near mealtime), desire to understand, being told to try it, and feeling appreciation for the body. Participants reported a high frequency of participation during guided physical movement-focused practices, with all but one user participating most to every time. Facilitators included being told to participate ("even though I didn't want to, I did it anyway"), increased positive outcome expectancies, and curiosity. Frequency of independent practice reported within app surveys was moderate with 50% of participants reporting sensory practices and 57% using breath meditation as a means to initiate sleep.

Mindfulness Timed Practice

Participants increased their ability to initiate and remain in a mindful state during timed practices over the 6-week study from an average of 31 (SD 21) seconds to 78 (SD 17) seconds. Participation was highest when the duration was 10 minutes or less, and no participant attempted the 15-minute practice.

Discussion

Mindfulness and Health

Mindfulness promotes present moment attention to and observation of the self and environment, which in turn may facilitate self-monitoring of behavior and improve self-regulatory capacities [2,21,22]. Mindfulness-based pediatric interventions have improved dietary quality [12], increased physical activity [12], decreased stress [23], and improved sleep [11], factors associated with healthy weight management. The amount of time required to practice mindfulness to improve behaviors is unknown [13,16]. However, research suggests practicing mindfulness for 10 to 15 minutes a day may improve health outcomes [24,25].

Principal Findings and Comparison With Prior Work

The b@Ease Mindfulness App provided 5.5 hours of mindfulness-based content and 3 hours of guided practice time over 42 days. This is similar to face-to-face mindfulness-based pediatric interventions which are often delivered less than an hour weekly for 8 to 12 weeks (8-12 days or 6-9 total hours) [13,26]. Inclusive of elements presented in face-to-face interventions, the program presents a light-hearted and entertaining way to encourage adolescents to practice achieving mindfulness states. However, unlike face-to-face programs, the b@Ease Mindfulness App provides flexible program delivery. Furthermore, the videos are easily adaptable as a program separate from the app and deliverable across a variety of platforms (eg, website). Participants in our study received 23 (SD 17) days of intervention and reported their experiences as highly acceptable and useful, and the app-based mindfulness program was feasibly delivered to this sample of teens.

Limitations

This study demonstrates the potential for the app to increase mindfulness in teens, but our method of measuring mindfulness has not been validated and is a limitation of the study. However, participant-reported time within a mindfulness state increased over the study (even though practice times also increased), suggesting the app increased the ability of participants to initiate and sustain longer periods of mindfulness states. App survey responses were used as a proxy to measure dose. Videos were streamed from YouTube to reduce file size, and long or repeated buffering reported by a few participants increased the likelihood of the app being closed before surveys were administered. Furthermore, app-generated data indicated high receipt of commands from mobile devices, but these data do not confirm the videos were viewed. We acknowledge the small sample size of this study is a limitation; however, it provides valuable information to allow iterative development of an app involving novel techniques for teaching mindfulness.

Conclusions

A mindfulness-based mobile app, the b@Ease Mindfulness App, was developed and tested for acceptance, utility, and feasibility in 14- to 18-year-old teens. The mobile app successfully delivered videos, which were typically viewed in less than 10 minutes every day for 6 weeks, to participants using an existing app platform. The mindfulness app was rated as an acceptable and useful program by participants, potentially providing greater reach to teens, a demographic who have expressed preference for virtual mindfulness-based health promotion programs [18]. Both comments and ratings support the app as a potential way to improve eating behaviors, encourage guided physical activity practices, facilitate sleep initiation, and improve overall well-being. Taken together, these factors may in turn improve weight-related behaviors [27,28]. Further refinement of this mobile app is warranted to confirm these posited impacts.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Surveys sent within the mobile app in the b@Ease Mindfulness App for Teens study.

[PDF File (Adobe PDF File), 72KB - resprot_v6i4e67_app1.pdf]

Multimedia Appendix 2

Poststudy survey questions of the b@Ease Mindfulness App for Teens study.

[PDF File (Adobe PDF File), 208KB - resprot_v6i4e67_app2.pdf]

Multimedia Appendix 3

Examples of comments submitted via the app by teens participating in the b@Ease Mindfulness App for Teens study.

[PDF File (Adobe PDF File), 22KB - resprot_v6i4e67_app3.pdf]

References

1. Baer R. Mindfulness training as a clinical intervention: a conceptual and empirical review. Clin Psychol Sci Pract 2003;10(2):125-143. [doi: 10.1093/clipsy.bpg015]
2. Bishop S, Lau M, Shapiro S, Carlson L, Anderson N, Carmody J, et al. Mindfulness: a proposed operational definition. Clin Psychol Sci Prac 2004;11(3):230-241. [doi: 10.1093/clipsy.bph077]
3. Brown KW, Ryan RM, Creswell JD. Addressing fundamental questions about mindfulness. Psychol Inq 2007 Oct 19;18(4):272-281. [doi: 10.1080/10478400701703344]
4. Bandura A. Social cognitive theory of self-regulation. Organ Behav Hum Decis Process 1991 Dec;50(2):248-287. [doi: 10.1016/0749-5978(91)90022-L]
5. Alert MD, Rastegar S, Foret M, Slipp L, Jacquart J, Macklin E, et al. The effectiveness of a comprehensive mind body weight loss intervention for overweight and obese adults: a pilot study. Complement Ther Med 2013 Aug;21(4):286-293. [doi: 10.1016/j.ctim.2013.05.005] [Medline: 23876558]
6. Kristeller J, Wolever RQ, Sheets V. Mindfulness-based eating awareness training (MB-EAT) for binge eating: a randomized clinical trial. Mindfulness 2013 Feb 1;5(3):282-297. [doi: 10.1007/s12671-012-0179-1]
7. Timmerman GM, Brown A. The effect of a mindful restaurant eating intervention on weight management in women. J Nutr Educ Behav 2012 Jan;44(1):22-28 [FREE Full text] [doi: 10.1016/j.jneb.2011.03.143] [Medline: 22243980]
8. Dalen J, Smith BW, Shelley BM, Sloan AL, Leahigh L, Begay D. Pilot study: Mindful Eating and Living (MEAL): weight, eating behavior, and psychological outcomes associated with a mindfulness-based intervention for people with obesity. Complement Ther Med 2010 Dec;18(6):260-264. [doi: 10.1016/j.ctim.2010.09.008] [Medline: 21130363]
9. Gregoski MJ, Barnes VA, Tingen MS, Harshfield GA, Treiber FA. Breathing awareness meditation and LifeSkills Training programs influence upon ambulatory blood pressure and sodium excretion among African American adolescents. J Adolesc Health 2011 Jan;48(1):59-64 [FREE Full text] [doi: 10.1016/j.jadohealth.2010.05.019] [Medline: 21185525]
10. Scime M, Cook-Cottone C. Primary prevention of eating disorders: a constructivist integration of mind and body strategies. Int J Eat Disord 2008 Mar;41(2):134-142. [doi: 10.1002/eat.20480] [Medline: 17957808]
11. Bootzin RR, Stevens SJ. Adolescents, substance abuse, and the treatment of insomnia and daytime sleepiness. Clin Psychol Rev 2005 Jul;25(5):629-644. [doi: 10.1016/j.cpr.2005.04.007] [Medline: 15953666]
12. Barnes VA. Impact of mindfulness-based eating awareness on diet and exercise habits in adolescents. Int J Complement Alt Med 2016 Feb 22;3(2). [doi: 10.15406/ijcam.2016.03.00070]
13. Zoogman S, Goldberg SB, Hoyt WT, Miller L. Mindfulness interventions with youth: a meta-analysis. Mindfulness 2014 Jan 15;6(2):290-302. [doi: 10.1007/s12671-013-0260-4]
14. Harnett P, Dawe S. The contribution of mindfulness-based therapies for children and families and proposed conceptual integration. Child Adolesc Ment Health 2011;17(4):195-208. [doi: 10.1111/j.1475-3588.2011.00643.x]
15. Burke CA. Mindfulness-based approaches with children and adolescents: a preliminary review of current research in an emergent field. J Child Fam Stud 2009 Jun 27;19(2):133-144. [doi: 10.1007/s10826-009-9282-x]
16. Carmody J, Baer RA. How long does a mindfulness-based stress reduction program need to be? A review of class contact hours and effect sizes for psychological distress. J Clin Psychol 2009 Jun;65(6):627-638. [doi: 10.1002/jclp.20555] [Medline: 19309694]
17. Turner T, Spruijt-Metz D, Wen CKF, Hingle MD. Prevention and treatment of pediatric obesity using mobile and wireless technologies: a systematic review. Pediatr Obes 2015 Dec;10(6):403-409. [doi: 10.1111/ijpo.12002] [Medline: 25641770]

18. Monshat K, Vella-Brodrick D, Burns J, Herrman H. Mental health promotion in the Internet age: a consultation with Australian young people to inform the design of an online mindfulness training programme. Health Promot Int 2012 Jun;27(2):177-186 [FREE Full text] [doi: 10.1093/heapro/dar017] [Medline: 21398335]
19. Spitzer R, Williams J, Kroenke K. Pfizer. Patient Health Questionnaire (PHQ-4) URL: http://www.phqscreeners.com/select-screener/116 [accessed 2015-04-20] [WebCite Cache ID 6kItCSXIo]
20. Garner DM, Olmsted MP, Bohr Y, Garfinkel PE. The eating attitudes test: psychometric features and clinical correlates. Psychol Med 1982 Nov;12(4):871-878. [Medline: 6961471]
21. Deci EL, Ryan RM. Self-determination theory: a macrotheory of human motivation, development, and health. Can Psychol 2008;49(3):182-185. [doi: 10.1037/a0012801]
22. Brown KW, Ryan RM. The benefits of being present: mindfulness and its role in psychological well-being. J Pers Soc Psychol 2003 Apr;84(4):822-848. [Medline: 12703651]
23. Biegel GM, Brown KW, Shapiro SL, Schubert CM. Mindfulness-based stress reduction for the treatment of adolescent psychiatric outpatients: A randomized clinical trial. J Consult Clin Psychol 2009 Oct;77(5):855-866. [doi: 10.1037/a0016241] [Medline: 19803566]
24. Rempel K. Mindfulness for children and youth: a review of the literature with an argument for school-based implementation. Can J Couns Psychother 2012;46(3):201-220 [FREE Full text]
25. Thompson M, Gauntlett-Gilbert J. Mindfulness with children and adolescents: effective clinical application. Clin Child Psychol Psychiatry 2008 Jul 01;13(3):395-407. [doi: 10.1177/1359104508090603]
26. Katterman SN, Kleinman BM, Hood MM, Nackers LM, Corsica JA. Mindfulness meditation as an intervention for binge eating, emotional eating, and weight loss: a systematic review. Eat Behav 2014 Apr;15(2):197-204. [doi: 10.1016/j.eatbeh.2014.01.005] [Medline: 24854804]
27. Gurgevich S, Nicolai J. Obesity and the stress connection: mind-body therapies for weight control. In: Mullin GE, Cheskin LJ, Matarese LE, editors. Integrative Weight Management. New York: Springer; 2014:413-421.
28. Torres SJ, Nowson CA. Relationship between stress, eating behavior, and obesity. Nutrition 2007 Nov;23(11-12):887-894. [doi: 10.1016/j.nut.2007.08.008] [Medline: 17869482]

Abbreviations

BMI: body mass index
EAT-26: Eating Attitudes Test
mHealth: mobile health
PHQ-4: Patient Health Questionnaire

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Editorial

Vascular Cognitive Impairment in a Memory Clinic Population: Rationale and Design of the "Utrecht-Amsterdam Clinical Features and Prognosis in Vascular Cognitive Impairment" (TRACE-VCI) Study

Jooske Marije Funke Boomsma[1,2], MD; Lieza Geertje Exalto[1], MD, PhD; Frederik Barkhof[3], MD, PhD; Esther van den Berg[1,4], PhD; Jeroen de Bresser[5], MD, PhD; Rutger Heinen[1], MD; Huiberdina Lena Koek[6], MD, PhD; Niels Daniël Prins[7], MD, PhD; Philip Scheltens[7], MD, PhD; Henry Chanoch Weinstein[2], MD, PhD; Wiesje Maria van der Flier[7,8], PhD; Geert Jan Biessels[1], MD, PhD

[1]Department of Neurology, Neurosurgery and Neuropsychology, Brain Centre Rudolf Magnus Institute, University Medical Centre Utrecht, Utrecht, Netherlands

[2]Onze Lieve Vrouwe Gasthuis (OLVG) West, Department of Neurology, Amsterdam, Netherlands

[3]Department of Radiology & Nuclear Medicine, VU University Medical Centre, Amsterdam, Netherlands

[4]Department of Neurology, Erasmus MC University Medical Centre, Rotterdam, Netherlands

[5]Department of Radiology, University Medical Centre Utrecht, Utrecht, Netherlands

[6]Department of Geriatrics, University Medical Centre Utrecht, Utrecht, Netherlands

[7]Alzheimer Centre and Department of Neurology, VU University Medical Centre, Amsterdam, Netherlands

[8]Department of Epidemiology and Biostatistics, VU University Medical Centre, Amsterdam, Netherlands

Corresponding Author:
Geert Jan Biessels, MD, PhD
Department of Neurology, Neurosurgery and Neuropsychology, Brain Centre Rudolf Magnus Institute
University Medical Centre Utrecht
PO Box 85500
Utrecht, 3508 GA
Netherlands
Phone: 31 88 7556866
Fax: 31 30 2542100
Email: G.J.Biessels@umcutrecht.nl

Abstract

Background: Vascular Cognitive Impairment (VCI) refers to cognitive dysfunction due to vascular brain injury, as a single cause or in combination with other, often neurodegenerative, etiologies. VCI is a broad construct that captures a heterogeneous patient population both in terms of cognitive and noncognitive symptoms and in terms of etiology and prognosis. This provides a challenge when applying this construct in clinical practice.

Objective: This paper presents the rationale and design of the TRACE-VCI study, which investigates the clinical features and prognosis of VCI in a memory clinic setting.

Methods: The TRACE-VCI project is an observational, prospective cohort study of 861 consecutive memory clinic patients with possible VCI. Between 2009 and 2013, patients were recruited through the Amsterdam Dementia Cohort of the VU University Medical Centre (VUMC) (N=665) and the outpatient memory clinic and VCI cohort of the University Medical Centre Utrecht (UMCU) (N=196). We included all patients attending the clinics with magnetic resonance imaging (MRI) evidence of vascular brain injury. Patients with a primary etiology other than vascular brain injury or neurodegeneration were excluded. Patients underwent an extensive 1-day memory clinic evaluation including an interview, physical and neurological examination, assessment of biomarkers (including those for Alzheimer-type pathologies), extensive neuropsychological testing, and an MRI scan of the brain. For prognostic analyses, the composite primary outcome measure was defined as accelerated cognitive decline (change of clinical dementia rating ≥1 or institutionalization) or (recurrent) major vascular events or death over the course of 2 years.

Results: The mean age at baseline was 67.7 (SD 8.5) years and 46.3% of patients (399/861) were female. At baseline, the median Clinical Dementia Rating was 0.5 (interquartile range [IQR] 0.5-1.0) and the median Mini-Mental State Examination score was 25 (IQR 22-28). The clinical diagnosis at baseline was dementia in 52.4% of patients (451/861), mild cognitive impairment in 24.6% (212/861), and no objective cognitive impairment in the remaining 23.0% (198/861).

Conclusions: The TRACE-VCI study represents a large cohort of well-characterized patients with VCI in a memory clinic setting. Data processing and collection for follow-up are currently being completed. The TRACE-VCI study will provide insight into the clinical features of memory clinic patients that meet VCI criteria and establish key prognostic factors for further cognitive decline and (recurrent) major vascular events.

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KEYWORDS

vascular cognitive impairment; memory clinic; small vessel disease; vascular disease; prognosis; dementia

Introduction

Cerebral vascular injury is a common cause of dementia and milder forms of cognitive dysfunction [1]. This vascular burden in cognitive decline and dementia is referred to as vascular cognitive impairment (VCI) [2,3]. According to the current literature, the concept or construct of VCI covers the entire spectrum of cognitive disorders ranging from mild cognitive impairment (MCI) through fully developed dementia, due to all forms of vascular brain injury [4]. It includes vascular disease as a single etiology, but also in combination with other, often neurodegenerative, causes of cognitive impairment [3,4].

VCI is thus a broad construct that captures a heterogeneous patient population both in terms of cognitive and noncognitive symptoms and in terms of etiology and prognosis. In clinical practice, VCI is mainly observed in stroke (in- and outpatient) services and in memory clinics (ie, outpatient cognitive impairment and dementia diagnostic centers). In a stroke clinic setting, mild to severe cognitive deficits may manifest themselves acutely or delayed after an ischemic or hemorrhagic stroke, in which case it is generally straightforward to establish a causal link between the vascular event and the cognitive deficit. In a memory clinic setting, patients more often present with insidious cognitive changes evolving over the course of many years. Vascular injury in these patients most commonly involves small vessel disease [5]. In many cases, multiple vascular lesions co-exist and often also co-occur with neurodegenerative pathologies, in particular Alzheimer's disease [3,4]. These mixed pathologies can make it more challenging to establish causality between the vascular lesions and the cognitive deficits in individual patients. In fact, there are no validated and generally accepted thresholds at which visible vascular brain injury can be considered "clinically relevant" in a patient presenting at a memory clinic. Moreover, it is still unclear to which extent vascular injury determines prognosis in a memory clinic setting, particularly when it co-occurs with other etiologies [6]. Addressing these uncertainties is important, given the frequent occurrence of vascular lesions in memory clinic patients. Yet, there are few studies on VCI in memory clinic cohorts [7].

The overall aim of the "Utrecht-Amsterdam clinical features and prognosis in vascular cognitive impairment" (TRACE-VCI) study is to establish the relation between different patterns of cerebral vascular injury and the cognitive profile and prognosis of patients in a memory clinic setting. We want to establish which clinical features of patients cluster in particular VCI phenotypes. In addition, we aim to identify key prognostic factors for further cognitive decline and/or (recurrent) major vascular events. To this end, we prospectively collected data of all patients with cognitive complaints and any burden of vascular brain injury on magnetic resonance imaging (MRI) from our memory clinics between 2009 and 2013. When this study was initiated, the construct of VCI had been introduced [2,3], but widely accepted clinical criteria for VCI were still lacking. In the absence of applicable VCI criteria, we intentionally developed nonrestrictive inclusion criteria for our study. We did not define minimal thresholds for cognitive impairment or specific patterns of vascular brain injury, in order to capture the whole spectrum of patients presenting at a memory clinic with cognitive complaints and visible vascular injury on MRI. We also did not select patients based on evidence for absence or presence of other neurodegenerative etiologies. This approach allowed us to study the full spectrum of cognitive disorders in relation to vascular brain injury as seen in a memory clinic and detect critical thresholds for clinically relevant vascular injury in this setting. Further subdivisions or selections according to stages of cognitive impairment, specific burden of vascular injury, and co-occurring pathologies will be applied as part of the analytic strategy of the TRACE-VCI study. This paper describes the design and protocol of the study including the baseline characteristics of the study population.

Methods/Design

Study Design

The TRACE-VCI study is a prospective observational follow-up study of 861 consecutive memory clinic patients from three Dutch outpatient clinics at two university hospitals. These tertiary referral clinics receive referrals from specialists from other memory clinics (eg, for a second opinion) but also direct referrals from general practitioners. Subjects were included from the outpatient clinic of the VU University Medical Centre (VUMC), registered in the Amsterdam Dementia Cohort (N=665) and from the two outpatient memory clinics of the University Medical Centre Utrecht (UMCU) (N=196) [8,9]. Patients with cognitive complaints and any burden of vascular brain injury on MRI (inclusion criteria are specified below) were prospectively included at their first visit to the clinics between September 2009 and December 2013. Each patient

received a standardized extensive 1-day memory clinic evaluation including an interview, physical and neurological examination, laboratory testing, extensive neuropsychological testing, and an MRI scan of the brain [4]. The study was approved by the institutional review board of the VUMC and the UMCU. All patients provided informed consent prior to research related procedures.

Follow-up investigation was performed around 2 years from baseline visit. Primary outcome variable for the prognostic studies was cognitive decline and/or (recurrent) major vascular events. These outcome variables are described in detail in the follow-up investigation section.

Study Objectives

The main objectives of the TRACE-VCI study are:

1. To establish the clinical features of memory clinic patients with vascular brain injury on MRI, addressing the following questions:
   - What are the patterns of vascular brain injury on MRI?
   - What are the cognitive profiles of the patients and how does the nature and severity of vascular brain injury relate to these profiles?
   - How does vascular brain injury relate to noncognitive outcomes, for example, depression, gait, and falls?
   - How do vascular brain injury and co-existent neurodegenerative disease interact?
   - Which features cluster in particular VCI phenotypes?
2. To identify key prognostic factors in patients with possible VCI at a memory clinic:
   - Which factors predict further cognitive decline or (recurrent) major vascular events?
   - Can poor outcome be reliably predicted on an individual basis?

Inclusion Criteria

We included patients with possible VCI with minimal constraints in terms of cognitive impairment and vascular brain injury. The presence of other co-occurring etiologies, such as neurodegenerative disease or depression was accepted because many patients with VCI have neurodegenerative disease as a comorbid etiology and depression can be a manifestation of cerebrovascular disease [3,10]. According to this rationale, possible VCI was defined according to the following criteria in the TRACE-VCI study.

Cognitive Impairment

Patients were included in the TRACE-VCI study regardless of the severity of cognitive impairment. The only criterion was that people had to be referred to the memory clinic because of suspected cognitive impairment. Patients were divided in three categories related to the extent of cognitive impairment: dementia, mild cognitive impairment (MCI), and a third group with no objective cognitive impairment (NOCI). The rationale for including patients with NOCI (also referred to as subjective cognitive impairment in memory clinics [11]) is that some patients with cognitive complaints and cognitive dysfunction due to vascular brain injury may not meet formal criteria for cognitive impairment on psychometric testing. We therefore decided to include all patients with cognitive complaints and evidence of vascular brain injury in the cohort and address different categories of cognitive impairment in the analyses.

Vascular Brain Injury

Any patient with at least a minimal burden of vascular brain injury on MRI was eligible for TRACE-VCI. As for cognition, we deliberately did not specify a threshold of injury. Moreover, we included patients regardless of the judgment of the treating physician on the clinical relevance of the vascular brain injury. To be included in TRACE-VCI, patients had to show at least one of the following forms of vascular brain injury on MRI, rated according to established criteria (Table 1) [12]:

1. white matter hyperintensities (WMH) with a Fazekas scale [13] grade ≥2
2. Fazekas scale grade 1 and an increased vascular risk defined as the presence of ≥2 vascular risk factors (hypertension, hypercholesterolemia, diabetes mellitus, obesity, current smoking, or a reported history of a vascular event other than stroke)
3. ≥1 lacunar infarct(s)
4. ≥1 nonlacunar infarct(s)
5. ≥1 cerebral microbleed(s)
6. ≥1 intracerebral hemorrhage

Table 1. Entry criteria for vascular brain injury[a].

Vascular brain injury	Mixed or single vascular injury, n (N=861)	Single vascular injury only, n (N=510)
Fazekas score 1 and ≥2 vascular risk factors	307	210
Fazekas score 2 or 3	399	160
≥1 Lacunar infarct(s)	188	13
≥1 Nonlacunar infarct(s)	83	4
≥1 Microbleed(s) (N=849)	368	120
≥1 Intracerebral hemorrhage(s)	16	3

[a]If there were missing data, the number (n=) is specifically mentioned.The first column presents the proportion of patients meeting the different entry criteria of vascular brain injury, either as a single criterion or in combination with others. The second column lists only patients who presented with a single category of vascular brain injury markers.

For criterion 2, the presence of hypertension was determined based on a self-reported medical history, use of antihypertensive drugs, or a newly diagnosed hypertension defined as a blood pressure of 140/90 mmHg or more, measured by means of a sphygmomanometer [14]. Hypercholesterolemia was determined based on medical history or medication use. Diabetes mellitus was based on medical history or medication use. Glucose or HbA1c levels were available from 96.9% (834/861) of patients. Patients were classified as newly diagnosed diabetes mellitus if they had a nonfasting glucose of ≥11.1 mmol/l or an HbA1c ≥48 mmol/mol (or ≥6.5%) [15]. Obesity was defined as a baseline body mass index (BMI) ≥30, calculated as weight in kilograms divided by height in meters squared. A self-reported history of a vascular event other than stroke was defined as a history of ischemic heart disease (myocardial infarction, surgery, or endovascular treatment for coronary artery disease) [16], peripheral arterial disease (any arterial occlusion or surgical intervention of a peripheral artery such as an abdominal or leg artery), and carotid artery stenting.

Exclusion Criteria

Patients with a monogenic nonvascular or vascular cause of cognitive dysfunction were excluded from the study population. These genetic diseases are relatively rare and have a distinct disease profile, which is in many aspects different from the other patients in this cohort. Patients with other nonvascular and nondegenerative primary causes of cognitive dysfunction such as a brain tumor, extensive traumatic head injury, substance or alcohol abuse, and multiple sclerosis were also excluded. Finally, patients with psychiatric diseases, other than depression, resulting in cognitive dysfunction were excluded.

Interview and Physical and Neurological Examination

Patients received a standardized diagnostic assessment performed by a neurologist or geriatrician including an interview on cognitive complaints and medical history, medication use (verified through listings provided by pharmacy), educational level, smoking, alcohol and drug abuse, family medical history, and social status. Patients were asked to bring a relative or good friend for an informant interview. Table 2 shows demographic characteristics and vascular risk factors of the study population.

Table 2. Demographic characteristics and vascular risk factors in the TRACE-VCI study.

	Patients (N=861)
Demographic characteristics	
Female, n (%)	399 (46.3)
Age in years, mean (SD)	67.7 (8.5)
Level of education (Verhage scale range 1-7)[a] (N=856), median (IQR)	5 (4-6)
Vascular risk factors, n (%)	
Hypertension	729 (84.7)
Medical history/use of medication	499 (68.4)
Newly diagnosed hypertension (>140/90mmHg) (N=834)	230 (31.6)
Hypercholesterolemia	386 (44.8)
Diabetes mellitus	169 (19.6)
Medical history/ use of medication	146 (86.4)
Newly diagnosed diabetes mellitus (N=834)	23 (13.6)
Current smoker (N=853)	173 (20.1)
Obesity (BMI ≥30) (N=848)	176 (20.4)
History of reported vascular events, n (%)	
History of reported stroke	78 (9.1)
History of reported vascular events other than stroke	86 (10.0)
History of ischemic heart disease[b]	60 (69.8)
History of carotid artery stenting	4 (4.7)
History of peripheral arterial disease[c]	31 (36.0)

[a]Verhage scale: (1) <6 years of primary education, (2) finished 6 years of primary education, (3) 6 years primary education and <2 years of low level secondary education, (4) 4 years of low level secondary education, (5) 4 years of average level secondary education, (6) 5 years of high level secondary education, (7) university degree [17].

[b]Myocardial infarction, surgery or endovascular treatment for coronary artery disease [16].

[c]Any arterial occlusion or surgical intervention of a peripheral artery (eg, abdominal or leg artery).

Physical examination included blood pressure measurement, height (centimeters), weight (kilograms), and BMI. Neurological examination was performed with special attention for higher cortical functions, focal deficits, extrapyramidal signs, balance, gait, primitive reflexes, and postural reaction.

Cognitive Assessment

Cognitive Screening and Education

We used the Dutch version of the Mini-Mental State Examination (MMSE; maximum score of 30) as a cognitive screening test [18]. Furthermore, the cognitive and self-contained part of the Cambridge Examination for Mental Disorders of the Elderly (CAMCOG; maximum score of 107) was performed [19]. Level of education was defined according to a 7-point rating scale (Verhage scale 1-7; low to high education) [17]. The severity of cognitive symptoms was assessed using the Clinical Dementia Rating (CDR; 0-3) global score [20].

Psychological Assessment and Other Questionnaires

Neuropsychiatric and behavioral symptoms were evaluated by the 15-item Geriatric Depression Scale (GDS) [21] and the Neuropsychiatric Inventory (NPI; maximum score of 144) [22]. The Disability Assessment for Dementia (DAD; maximum score of 100) questionnaire investigated functional decline [23]. The NPI and DAD were collected through the use of a proxy-respondent. Table 3 shows the cognitive and psychological screening scores at baseline.

Table 3. Cognitive and psychological assessment in the TRACE-VCI population (N=861).

Instruments/methods	n (%)	Median (IQR)
Global functioning		
DAD	738 (85.7)	89 (75-98)
Mood		
GDS	815 (94.7)	3 (2-5)
NPI[a]	604 (70.2)	10 (4-19)
Measures of global cognitive status		
CDR	861 (100)	0.5 (0.5-1)
MMSE score	856 (99.4)	25 (22-28)
CAMCOG[b]	698 (81.1)[c]	82 (69-91)

[a]A higher NPI score relates to more neuropsychiatric symptoms.

[b]Reference values of the CAMCOG score depend on primary education level and age.

[c]The outpatient memory clinic of the UMCU did not perform the CAMCOG, and the VCI outpatient clinic of the UMCU introduced it at a later stage; therefore, 163 (18.9%) were missing

Neuropsychological Assessment

All participants performed an extensive neuropsychological examination, with some variation between the centers and over time. This battery has been established through a Dutch multicenter university memory clinic research program on diagnosis and prognosis of cognitive impairment and dementia [8]. Only tasks that were available by the majority of patients (>80%) were included. The tasks were summarized in five major widely used cognitive domains to reduce the amount of neuropsychological variables for statistical analysis and clinical interpretation: (1) working memory, (2) memory, (3) attention and executive functioning, (4) processing speed, and (5) perception and construction. The tests included in each of the domains are listed in Table 4.

The domain working memory was assessed by the Digit Span of the Wechsler Adult Intelligence Scale – 3rd edition (WAIS-III). Patients were asked to verbally repeat series of digits of increasing length in forward and backward condition.

The domain memory was assessed by the Dutch version of the Rey Auditory Verbal Learning Test (RAVLT). For the RAVLT, the total number of words remembered in five learning trials was recorded and the delayed recall and recognition tasks were used. Furthermore, the Visual Association Test (VAT) part A was included to assess visuospatial association learning.

The domain attention and executive functioning was assessed using the ratio of the Trail Making Test part B and A (TMT-B and TMT-A), the Stroop Color Word Test, and the category naming tasks (animal naming, 1 minute) and lexical fluency tasks (letters, 1 minute). The used letters in the lexical fluency tasks were different between the clinics. The letters “N” and “A” were used in 66 patients of the VCI outpatient clinic UMCU. The letters “D,” “A,” and “T” were used in 626 patients of the Amsterdam Dementia Cohort VUMC. The total number of correct responses was recorded and averaged over the evaluated amount of letters.

The domain information processing speed was assessed by the TMTA-A, the Stroop Color Word Test I and II, and the Digit Symbol-Coding Test (DSCT) of the WAIS-III or the Letter Digit Substitution Test (LDST). In both the DSCT and the LDST, patients were asked to copy as many symbols or digits according to a code key in a specific amount of time. The DSCT was performed in 65 patients and the LDST in 696 patients. The difference in time (60 vs 90 seconds) was resolved by the use of *Z* scores for each version in the creation of the cognitive domain.

Table 4. Neuropsychological test scores and cognitive domains in the study population (N=861).

Neuropsychological tests and cognitive domains	Patients, n (%)	Raw test scores, mean (SD)
Working memory	721 (83.7)	
WAIS-III Digit Span forward [24]	715 (83.0)	5.4 (1.1)
WAIS -III Digit Span backward	721 (83.7)	4.0 (1.0)
Memory	854 (99.2)	
RAVLT trials 1-5 [25]	815 (94.7)	28.9 (11.5)
VAT part A [26]	783 (90.9)	8.9 (3.7)
RAVLT delayed recall	810 (94.1)	4.3 (3.8)
RAVLT recognition	806 (93.6)	25.0 (4.1)
Attention and executive functioning	848 (98.5)	
Ratio TMTA part B/TMT part A [27]	635 (73.8)	3.1 (1.4)
Stroop Color Word Test III/(I and II) [28]	729 (84.7)	1.2 (0.4)
Category fluency (Animals) [29]	833 (96.7)	15.0 (6.6)
Letter fluency [29]		
N+A	66 (7.6)	17.5 (7.8)
D+A+T	626 (72.7)	26.8 (13.2)
Information processing speed	837 (97.2)	
TMTA part A	792 (92.0)	72.0 (55.2)
Stroop Color Word Test I	796 (92.5)	60.3 (25.5)
Stroop Color Word Test II	788 (91.5)	86.2 (40.6)
WAIS-III [24]		
SDMT	65 (7.5)	42.0 (15.2)
LDST	696 (80.8)	33.1 (12.7)
Perception and construction	705 (81.9)	
Incomplete Letters	696 (80.8)	17.4 (4.0)
Dot Counting	682 (79.2)	9.3 (1.3)

The cognitive domain perception and construction was made using the Visual Object and Space Perception Battery, administering two separate tests known as the Incomplete Letters and Dot Counting. The numbers of correct responses were recorded.

Z scores were created for each individual test (reversed *Z* scores for the TMT and Stroop Color Word Test). The test *Z* scores were averaged to create domain *Z* scores. If patients were unable to perform a test for various reasons, the test was defined as a missing variable. Where applicable, reports on the TRACE-VCI study will report proportions of subjects with missing values and explore potential biases. If individual test scores were missing, the domain *Z* score was based only on the available tests.

Laboratory Testing

Plasma fasting or nonfasting glucose level, cerebrospinal fluid (CSF), and DNA for apolipoprotein E (APOE) genotyping were collected in a subset of the study population. Collection of CSF biomarkers is not a standard procedure in memory clinics in the Netherlands, but in our centers it is performed quite frequently, at the discretion of the doctor and the patient. CSF concentrations of amyloid B 1-42 (Aβ42), tau and/or total tau phosphorylated at threonine 181 (p-tau) were measured at a central laboratory for clinics at the Department of Clinical Chemistry of the VUMC in 62.8% (541/861) of patients [30]. In 51.6% (444/861) of patients, APOE genotyping was performed. For APOE genotyping, DNA was isolated from 10ml ethylenediamine tetraacetic acid blood. Subjects were classified as APOE e4 carriers if they had one or two e alleles and as noncarriers if they had no e4 alleles.

Table 5. Brain MRI acquisition in the study population (N=861).

	Model	Field strength (Tesla)	Patients, n (%)
GE Medical Systems			
	Signa HDxt	1.5	71 (8.2)
	Signa HDxt	3.0	475 (55.2)
	Discovery MR 750	3.0	73 (8.5)
Philips Medical Systems			
	Ingenuity	3.0	44 (5.1)
	Ingenia	3.0	152 (17.7)
	Achieva	3.0	40 (4.6)
Others[a]			6 (0.7)

[a]1.5 Tesla GE Medical Systems Signa Excite, n=1 (0.1%); 1.5 Tesla Philips Medical Systems Achieva, n=2 (0.2%); 1.5 Tesla Philip Medical Systems Intera, n=1 (0.1%); 1.5 Tesla Sonata Siemens, n=2 (0.2%).

MRI Assessment

Brain MRI Scan

Brain MRI scans were performed on a 3.0 Tesla (94.1%, 810/861) or 1.5 Tesla MRI scanner (5.9%, 51/861). Most scans were performed on a GE (72.0%, 620/861) or Philips (27.8%, 239/861) MRI scanner (Table 5). The MRI scan protocol included the following sequences: 3D T1-weighted, T2-weighted, T2*-weighted/susceptibility-weighted imaging (SWI) and fluid-attenuated inversion recovery (FLAIR) sequences. A total of 850 (98.7%) patients were scanned using all of these sequences. In 11 patients (1.3%), a 2D T1-weighted sequence was acquired instead of a 3D T1-weighted sequence and/or no FLAIR sequence was available.

The MRI sequence parameters were as follows:

- 1.5 Tesla GE Signa HDxt—3D T1-weighted sequence (172 slices, voxel size: 0.98x0.98x1.50 mm^3, Repetition Time (TR)/Echo Time (TE): 12.3/5.2 ms), 3D FLAIR sequence (128 slices, voxel size: 1.21x1.21x1.30 mm^3, TR/TE/Inversion Time (TI): 6500/117/1987 ms), 2D T2-weighted sequence (48 slices, voxel size: 0.98x0.98x3.00 mm^3, TR/TE: 1000/23.9 ms), 2D T2*-weighted sequence (48 slices, voxel size: 0.98x0.98x3,00 mm^3, TR/TE: 1000/24 ms)
- 3.0 Tesla GE Signa HDxt—3D T1-weighted sequence (176 slices, voxel size: 0.94x0.94x1.00 mm^3, TR/TE: 7.8/3.0 ms), 3D FLAIR sequence (132 slices, voxel size: 0.98x0.98x1.2 mm^3, TR/TE/TI: 8000/126/2340), 2D T2-weighted sequence (48 slices, voxel size: 0.49x0.49x3.00 mm^3, TR/TE/: 8610/112 ms), 3D SWI sequence (48 slices, voxel size: 0.49x0.49x3.00 mm^3, TR/TE: 31/25 ms)
- 3.0 Tesla GE Discovery MR 750—3D T1-weigthed sequence (176 slices, voxel size: 0.94x0.94x1.00 mm^3, TR/TE: 8.2/3.2 ms), 3D FLAIR sequence (160 slices, voxel size: 0.98x0.98x1.2 mm^3, TR/TE/TI: 8000/130/2340 ms), 2D T2-weighted sequence (48 slices, voxel size: 0.49x0.49x3.00 mm^3, TR/TE/: 8300/112 ms), 3D SWI sequence (44 slices, voxel size: 0.49x0.49x3.00 mm^3, TR/TE: 31/25 ms)
- 3.0 Tesla Philips Ingenuity—3D T1-weighted sequence (180 slices, voxel size: 0.87x0.87x1.00 mm^3, TR/TE: 9.9/4.6 ms, 3D FLAIR sequence (321 slices, voxel size: 1.04x1.04x0.56 mm^3, TR/TE/TI: 4800/279/1650 ms), 2D T2-weighted sequence (45 slices, voxel size: 0.49x0.49x3.3 mm^3, TR/TE: 2500-5000/100 ms, 3D SWI sequence (247 slices, voxel size: 0.43x0.43x0.60 mm^3, TR/TE: 29x20 ms)
- 3.0 Tesla Philips Achieva and Ingenia—3D T1-weighted sequence (192 slices, voxel size: 1.00x1.00x1.00 mm^3, TR/TE: 7.9/4.5 ms), 2D FLAIR sequence (48 slices, voxel size: 0.96x0.95x3.00 mm^3, TR/TE/TI: 11000/125/2800 ms), 2D T2-weighted sequence (48 slices, voxel size: 0.96x0.96x3.00 mm^3, TR/TE/TE2: 3198/140 ms), 2D T2*-weighted sequence (48 slices, voxel size: 0.96x0.96x3.00 mm^3, TR/TE: 1653/20 ms)

Visual MRI Ratings

Medial temporal lobe atrophy (MTA) was visually rated (possible range of scores for each side, 0-4) on reconstructions (perpendicular to the long axis of the hippocampus) of the 3D T1-weighted images [31]. White matter hyperintensities (WMH) were rated using the Fazekas scale (WMH grade 0-3: none or a single punctate lesion, multiple punctate lesions, beginning confluence of lesions, large confluent lesions) on the FLAIR images [13]. Lacunar infarct(s), (sub)cortical infarct(s), microbleed(s), and intracerebral hemorrhage(s) were all rated in line with the STRIVE (Standards for Reporting Vascular Changes on Neuroimaging) criteria [12]. Ratings were performed by or under supervision of a neuroradiologist (in training).

Image Processing

Despite heterogeneity in MRI acquisition, we will obtain volumetric brain measures for all subjects. Total brain volume, white and gray matter volume, CSF volume, intracranial volume,

and WMH volume will be calculated for all subjects, using the 3D T1-weighted sequences. We are currently evaluating automated image processing methods that can best accommodate differences in acquisition. Final methods will be selected based on accuracy across the different types of MRI acquisitions and robustness across field strength [32,33].

Clinical Diagnosis

Clinical diagnoses were established at multidisciplinary consensus meetings after the 1-day memory clinic evaluation at participating centers. Diagnoses were verified by the researchers of the TRACE-VCI project based on screening of medical files. Patients were divided in three categories of severity of cognitive impairment: dementia, MCI, and NOCI. Table 6 presents the different categories.

Patients were diagnosed with dementia if there was a clear decline in cognitive function defined as a deficit in ≥2 cognitive domains at neuropsychological testing and interference in daily living [4]. Dementia was further classified due to its main etiology, based on internationally established diagnostic criteria without knowledge of CSF biomarkers or APOE genotyping results, in a vascular [34], neurodegenerative [35-37], or unknown origin (Table 6).

MCI was a clinical diagnosis defined as complaints of deterioration in cognitive function from a prior baseline and objective evidence of impairment in at least one cognitive domain. Instrumental activities of daily living were normal or only mildly impaired [4].

Finally, NOCI was defined as having cognitive complaints, but no objective cognitive impairment on neuropsychological testing. In a memory clinic setting, such patients are also referred to as having subjective complaints or subjective cognitive impairment [11].

Table 6. Severity of cognitive impairment and clinical diagnosis (N=861).

	Patients, n (%)
No objective cognitive impairment	198 (23.0)
Mild cognitive impairment	213 (24.7)
Dementia	450 (52.3)
Vascular [34]	37 (8.2)
Neurodegenerative	387 (85.8)
Alzheimer's disease [36]	305 (78.8)
Frontotemporal dementia [37]	25 (6.5)
Lewy body dementia [35]	20 (5.2)
Others[a]	37 (9.6)
Unknown etiology[b]	27 (6.0)

[a]Such as Primary Progressive Aphasia [38], Cortical Basal Syndrome [39], and Progressive Supranuclear Palsy [40].

[b]Dementia of unknown origin; further examination needed to state diagnosis.

Follow-Up Investigation

Collection of Follow-Up Data

Follow-up data were collected during a visit at the outpatient clinic around 2 years from baseline visit. At the baseline visit, the doctor and patient decided if a follow-up visit was necessary and in the best interest of the patient. All patients who did not attend the outpatient clinic after approximately 2 years were contacted by phone and a close relative or friend was also contacted to complement the information. If patients could not provide information themselves, only close relatives of friends were interviewed. If patients were unreachable or gave no permission to contact them personally in the future, the general practitioner or doctor of the nursing home was contacted if permitted by informed consent at baseline visit.

Primary Outcome Measure of Prognostic Studies

The primary goal of the prognostic studies of the TRACE-VCI study is to identify which patients have a poor clinical outcome in the years following the initial visit. We therefore defined a composite primary outcome measure that is robust, clinically relevant, and could also be collected from patients who did or could not visit the outpatient clinic again after 2 years. Follow-up was not collected from patients with a low MMSE [22] score of <20 or a CDR [25] of >1 at baseline visit. This included 150 (17.4%) of all patients who were included at baseline.

For the primary prognostic analyses in the TRACE-VCI study, poor clinical outcome was defined as a composite of (1) marked cognitive decline, (2) occurrence of a major vascular event, and (3) death. Marked cognitive decline was defined as a change in CDR of ≥1 and/or institutionalization due to cognitive dysfunction during the follow-up period [41]. Occurrence of a major vascular event during follow-up was defined as a stroke, myocardial infarction, or clinical manifestations of arterial disease requiring surgical or endovascular intervention (eg, a coronary bypass operation, carotid artery stenosis, arterial dotter procedure, or stent placement).

Additional Follow-Up Measurements

During the outpatient follow-up visit and by telephone contact, additional follow-up information was collected. The standardized DAD questionnaire was collected from a proxy-respondent [23]. The opinion of the patient and proxy-respondent on progression, stability, or improvement of cognitive symptoms was recorded. Noncognitive outcome information collected during the outpatient clinical visit or by telephone contact included the use of a walking aid, walking distance, number of falls, and the possible related injury. Relevant changes in medical history were also recorded in the database.

The majority of patients who had an outpatient follow-up visit also underwent an extensive neuropsychological examination. Cognitive domains were recreated by the use of *Z* scores, using the same tests as on baseline visit evaluating changes in the different cognitive domains.

Statistical Analysis

Sample Size Considerations

The TRACE-VCI study was designed to address several research questions. Therefore, statistical power is not a unitary construct for the study. Overall, the total cohort of 861 subjects will allow exploration of prognostic models including up to 10 predictors, at a power of 0.8, to detect small effect sizes (Cohen's d=0.2 and f^2=0.02)

Planned Analysis

For the first aim—establishing clinical features of different patterns of brain injury—cross-sectional analysis on baseline will be performed on all subjects. Regression analyses will be used with adjustments for age, level of education, and gender to investigate the association between vascular brain injury and cognitive and noncognitive outcomes. Because most injury types are present in >100 patients (see Table 1), we will be able to detect small to moderate effect sizes (Cohen's d=0.2-0.4) between groups of patients with different lesion types (power 0.8, alpha<.05). Depending on the research questions, other covariates may be added stepwise to the model to investigate the relation further. Factor analyses will be used to investigate clusters of VCI phenotypes.

For the second aim, identification of key prognostic factors, longitudinal analysis will be performed on all patients that were eligible for follow-up (as described above). The prognostic value of a variable will be examined using Cox proportional hazard models. Accelerated cognitive decline, new major vascular events, or death are the primary outcome measures. We will start with univariate models of all possible predictors with age, level of education, and gender as covariates.

Discussion

Principal Considerations

The TRACE-VCI study is a large prospective cohort study evaluating the clinical features and prognosis of VCI in a memory clinic population. The majority of previous studies on vascular brain injury and cognition are either based on the general population, focusing on patients who experienced a stroke or transient ischemic attack (TIA) [7], or primarily address one particular type of vascular brain injury, such as WMH [42]. It is clearly important to document which clinical phenotypes related to vascular injury can be identified in a memory clinic setting and which factors determine prognosis for the individual patient. With regard to clinical phenotypes, it is important to know to which extent the type or location of vascular injury determines the cognitive profile. This may support a more accurate diagnosis, particularly in the context of co-occurring neurodegenerative aetiologies, which will be much more common in memory clinic patients than in other populations. The TRACE-VCI study will explore these profiles and, because of availability of CSF biomarkers in a substantial proportion of patients, will be able to explore the interaction between vascular brain injury and processes related to Alzheimer's disease. With regard to prognosis, risk factors for cognitive dysfunction in the general population may not necessarily determine the rate of further cognitive decline among people attending a memory clinic. Identification of specific VCI phenotypes in a memory clinic setting may also support selection of patients for potential future treatment trials. The TRACE-VCI study collected this information in the context of actual clinical practice.

The operational definition of possible VCI as developed for the TRACE-VCI study should be addressed in this discussion. When the TRACE-VCI study was initiated in 2009, the construct of VCI had been introduced [2,3], but widely accepted clinical criteria for VCI were still lacking. We intentionally developed nonrestrictive criteria for our study. We chose not to define minimal thresholds for cognitive dysfunction. The rationale for this is that patients with cognitive decline as a result of vascular brain injury may not always develop cognitive deficits that are severe enough to be classified as MCI. A strict method to separate people with these more subtle cognitive changes from patients who complain, but actually have no change in cognitive performance at all, is not available. Hence, cognitive complaints are the entry criterion for the TRACE-VCI study and people without cognitive impairment are classified as NOCI, also referred to as subjective cognitive impairment [11]. We decided not to use the label subjective because this term has a connotation of nonconfirmed or even psychogenic complaints in medical practice. We did specify a minimal burden of vascular injury because the construct of VCI requires the presence of vascular brain injury. We deliberately did not include a criterion on a presumed causal relation between cognitive dysfunction and the observed vascular injury as this may in many cases rely on assumption, while the main purpose of the TRACE-VCI study is to determine if vascular brain injury really matters in memory clinic patients. Importantly, we did not exclude patients with evidence of co-occurring neurodegenerative disease as the construct of VCI also concerns the presence of vascular as well as neurodegenerative etiologies [3,4].

After the initiation of the TRACE-VCI study, diagnostic criteria for VCI have been proposed by international working groups, including criteria for Vascular Cognitive Impairment from the American Heart Association/American Stroke Association (AHA/ASA) [4] and criteria for vascular cognitive disorders

from the International Society of Vascular Behavioural and Cognitive Disorders (VasCog) Society [43]. Unlike our operational VCI criteria, both the AHA/ASA and the VasCog criteria define a threshold for severity of cognitive dysfunction. When appropriate, analyses in the TRACE-VCI can be adapted to modify these criteria by excluding people with NOCI. The AHA/ASA criteria also apply to patients with evidence for co-occurring neurodegenerative or other causes of cognitive impairment, but these patients are labeled as possible VCI, similar to our operational definition of VCI. This is different from the VasCog criteria [43], which relates only to subjects with evidence for predominantly vascular etiology of cognitive impairment. The VasCog criteria consider evidence of other etiologies, including a neurodegenerative disorder, as an exclusion criterion for the diagnosis VCI. With regard to the causality of the relation between cognitive dysfunction and vascular injury, the AHA/ASA criteria distinguish between probable and possible VCI. Probable VCI is diagnosed when a clear temporal relationship between a vascular event (eg, a clinical stroke) and onset of cognitive deficits is present or if there is a clear relationship in the severity and pattern of cognitive impairment and the presence of diffuse subcortical cerebrovascular disease pathology (eg, as in cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy). This temporal relationship is also recorded in the TRACE-VCI database, and we can apply these AHA/ASA criteria also in our dataset.

A key objective of TRACE-VCI is to identify prognostic factors in patients with VCI. To this end, we wanted to define a clinically meaningful outcome measure that we could collect in the majority of patients and also in those who could or would not revisit the clinic for follow-up. We chose a composite measure that reflects the primary poor outcome of VCI: marked cognitive decline, a major vascular event, or death. We did perform repeated cognitive assessments in patients who attended the outpatient clinic again, and we will perform analyses on these dates. However, we decided not to base our definition of marked cognitive decline on these assessments as that would induce substantial attrition.

Strengths and Limitations

A strength of the TRACE-VCI study is that it addresses the clinical features and prognosis of VCI in a memory clinic setting. It thus fills a knowledge gap, as there are few available cohort studies of VCI in this particular setting [7]. As a consequence, despite the fact that vascular brain injury on MRI is a very common finding in memory clinic patients, uncertainty can exist about its clinical and prognostic relevance in individual cases. TRACE-VCI includes a large cohort of memory clinic patients with 2-year follow-up and detailed data on cognitive performance, imaging markers, and comorbid conditions. A potential weakness of our study is that patients were included at tertiary referral centers, which may affect generalizability of the findings. Moreover, although patients were evaluated in a standardized fashion, the study does rely on data collection in the context of clinical care. Therefore, there is some heterogeneity in data acquisition (eg, MRI protocols) and not all parameters are available for all participants. Where applicable, reports on the TRACE-VCI study will specify proportions of subjects with missing values and explore potential biases. Finally, aspects of medical history (eg, vascular events) were based on self-report, which could be affected by recall bias. Yet, in our clinics the information is verified with an informant (eg, relative) and the information provided by the referring physician. Moreover, all patients bring a medication list provided by their pharmacy, and this is also scrutinized by the treating physician to identify relevant comorbidities.

Conclusion

The follow-up of our study is nearly complete, and data-cleaning and processing are in progress. The TRACE-VCI cohort study will provide detailed information on the phenotypes of VCI in a memory clinic setting to reveal the progression of cognitive decline and identify prognostic factors.

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The following are the members of the TRACE-VCI study group (in alphabetical order, per department):

VU University Medical Centre, Amsterdam, The Netherlands: 1) Alzheimer Centre and Department of neurology: MR Benedictus, J Bremer, WM van der Flier, J Leijenaar, ND Prins, P Scheltens, BM Tijms; 2) Department of Radiology and Nuclear Medicine: F Barkhof, MP Wattjes; 3) Department of Clinical Chemistry: CE Teunissen; 4) Department of Medical Psychology: T Koene.

University Medical Centre Utrecht, Utrecht, The Netherlands: 1) Department of Neurology: E van den Berg, GJ Biessels, JMF Boomsma, LG Exalto, DA Ferro, CJM Frijns, ON Groeneveld, R Heinen, NM van Kalsbeek, JH Verwer; 2) Department of Radiology/Image Sciences Institute: J de Bresser, HJ Kuijf; 3) Department of Geriatrics: HL Koek.

Onze Lieve Vrouwe Gasthuis (OLVG) West, Amsterdam, The Netherlands: 1) Department of Neurology: JMF Boomsma, HM Boss, HC Weinstein.

Conflicts of Interest

None declared.

References

1. Iadecola C. The pathobiology of vascular dementia. Neuron 2013 Nov 20;80(4):844-866 [FREE Full text] [doi: 10.1016/j.neuron.2013.10.008] [Medline: 24267647]
2. Hachinski V. Vascular dementia: a radical redefinition. Dementia 1994;5(3-4):130-132. [Medline: 8087166]
3. O'Brien JT, Erkinjuntti T, Reisberg B, Roman G, Sawada T, Pantoni L, et al. Vascular cognitive impairment. Lancet Neurol 2003 Feb;2(2):89-98. [Medline: 12849265]
4. Gorelick PB, Scuteri A, Black SE, Decarli C, Greenberg SM, Iadecola C, American Heart Association Stroke Council, Council on Epidemiology Prevention, Council on Cardiovascular Nursing, Council on Cardiovascular Radiology Intervention, Council on Cardiovascular Surgery Anesthesia. Vascular contributions to cognitive impairment and dementia: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2011 Sep;42(9):2672-2713 [FREE Full text] [doi: 10.1161/STR.0b013e3182299496] [Medline: 21778438]
5. van Buchem MA, Biessels GJ, Brunner la Rocca HP, de Craen AJM, van der Flier WM, Ikram MA, et al. The heart-brain connection: a multidisciplinary approach targeting a missing link in the pathophysiology of vascular cognitive impairment. J Alzheimers Dis 2014;42 Suppl 4:S443-S451. [doi: 10.3233/JAD-141542] [Medline: 25213769]
6. Biessels GJ. Diagnosis and treatment of vascular damage in dementia. Biochim Biophys Acta 2016 May;1862(5):869-877. [doi: 10.1016/j.bbadis.2015.11.009] [Medline: 26612719]
7. METACOHORTS Consortium, Dichgans M, Wardlaw J, Smith E, Zietemann V, Seshadri S, et al. METACOHORTS for the study of vascular disease and its contribution to cognitive decline and neurodegeneration: An initiative of the Joint Programme for Neurodegenerative Disease Research. Alzheimers Dement 2016 Aug 1 [FREE Full text] [doi: 10.1016/j.jalz.2016.06.004] [Medline: 27490018]
8. Aalten P, Ramakers IH, Biessels GJ, de Deyn PP, Koek HL, OldeRikkert MG, et al. The Dutch Parelsnoer Institute--Neurodegenerative diseases; methods, design and baseline results. BMC Neurol 2014 Dec 31;14:254 [FREE Full text] [doi: 10.1186/s12883-014-0254-4] [Medline: 25551191]
9. van der Flier WM, Pijnenburg YAL, Prins N, Lemstra AW, Bouwman FH, Teunissen CE, et al. Optimizing patient care and research: the Amsterdam Dementia Cohort. J Alzheimers Dis 2014;41(1):313-327. [doi: 10.3233/JAD-132306] [Medline: 24614907]
10. Firbank MJ, Teodorczuk A, van der Flier WM, Gouw AA, Wallin A, Erkinjuntti T, et al. Relationship between progression of brain white matter changes and late-life depression: 3-year results from the LADIS study. Br J Psychiatry 2012 Jul;201(1):40-45 [FREE Full text] [doi: 10.1192/bjp.bp.111.098897] [Medline: 22626634]
11. Jessen F, Amariglio RE, van BM, Breteler M, Ceccaldi M, Chételat G, Subjective Cognitive Decline Initiative (SCD-I) Working Group. A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. Alzheimers Dement 2014 Nov;10(6):844-852 [FREE Full text] [doi: 10.1016/j.jalz.2014.01.001] [Medline: 24798886]
12. Wardlaw JM, Smith EE, Biessels GJ, Cordonnier C, Fazekas F, Frayne R, STandards for ReportIng Vascular changes on nEuroimaging (STRIVE v1). Neuroimaging standards for research into small vessel disease and its contribution to ageing and neurodegeneration. Lancet Neurol 2013 Aug;12(8):822-838 [FREE Full text] [doi: 10.1016/S1474-4422(13)70124-8] [Medline: 23867200]
13. Fazekas F, Chawluk JB, Alavi A, Hurtig HI, Zimmerman RA. MR signal abnormalities at 1.5 T in Alzheimer's dementia and normal aging. AJR Am J Roentgenol 1987 Aug;149(2):351-356. [doi: 10.2214/ajr.149.2.351] [Medline: 3496763]
14. Whitworth JA, World Health Organization, International Society of Hypertension Writing Group. 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. J Hypertens 2003 Nov;21(11):1983-1992. [doi: 10.1097/01.hjh.0000084751.37215.d2] [Medline: 14597836]
15. Chamberlain JJ, Rhinehart AS, Shaefer CF, Neuman A. Diagnosis and Management of Diabetes: Synopsis of the 2016 American Diabetes Association Standards of Medical Care in Diabetes. Ann Intern Med 2016 Apr 19;164(8):542-552. [doi: 10.7326/M15-3016] [Medline: 26928912]
16. Manschot SM, Biessels GJ, de VH, Algra A, Rutten GEHM, van der Grond J, Utrecht Diabetic Encephalopathy Study Group. Metabolic and vascular determinants of impaired cognitive performance and abnormalities on brain magnetic resonance imaging in patients with type 2 diabetes. Diabetologia 2007 Nov;50(11):2388-2397 [FREE Full text] [doi: 10.1007/s00125-007-0792-z] [Medline: 17764005]
17. Verhage F. Intelligentie en leeftijd: onderzoek bij Nederlanders van twaalf tot zevenenzeventig jaar. Netherlands: Van Gorcum; 1964:-98.
18. Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975 Nov;12(3):189-198. [Medline: 1202204]
19. Roth M, Tym E, Mountjoy CQ, Huppert FA, Hendrie H, Verma S, et al. CAMDEX. A standardised instrument for the diagnosis of mental disorder in the elderly with special reference to the early detection of dementia. Br J Psychiatry 1986 Dec;149:698-709. [Medline: 3790869]

20. Hughes CP, Berg L, Danziger WL, Coben LA, Martin RL. A new clinical scale for the staging of dementia. Br J Psychiatry 1982 Jun;140:566-572. [Medline: 7104545]
21. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res 1982;17(1):37-49. [Medline: 7183759]
22. Cummings JL, Mega M, Gray K, Rosenberg-Thompson S, Carusi DA, Gornbein J. The Neuropsychiatric Inventory: comprehensive assessment of psychopathology in dementia. Neurology 1994 Dec;44(12):2308-2314. [Medline: 7991117]
23. Gélinas I, Gauthier L, McIntyre M, Gauthier S. Development of a functional measure for persons with Alzheimer's disease: the disability assessment for dementia. Am J Occup Ther 1999;53(5):471-481. [Medline: 10500855]
24. Moses JA, Pritchard DA, Adams RL. Neuropsychological information in the Wechsler Adult Intelligence Scale-Revised. Arch Clin Neuropsychol 1997;12(2):97-109 [FREE Full text] [Medline: 14588421]
25. Van der Elst Wim W, van Boxtel MPJ, van Breukelen GJP, Jolles J. Rey's verbal learning test: normative data for 1855 healthy participants aged 24-81 years and the influence of age, sex, education, and mode of presentation. J Int Neuropsychol Soc 2005 May;11(3):290-302. [doi: 10.1017/S1355617705050344] [Medline: 15892905]
26. Lindeboom J, Schmand B, Tulner L, Walstra G, Jonker C. Visual association test to detect early dementia of the Alzheimer type. J Neurol Neurosurg Psychiatry 2002 Aug;73(2):126-133 [FREE Full text] [Medline: 12122168]
27. Corrigan JD, Hinkeldey NS. Relationships between parts A and B of the Trail Making Test. J Clin Psychol 1987 Jul;43(4):402-409. [Medline: 3611374]
28. Stroop J. Studies of interference in serial verbal reactions. J Exp Psych Gen 1935;121(1):15-23.
29. Deelman BG, Liebrand WB, Koning-Haanstra M, van den Burg W. [Measurements of aphasic disorders. A brief description of the SAN-battery]. Gerontologie 1980 Feb;11(1):17-21. [Medline: 7399336]
30. Mulder C, Verwey NA, van der Flier WM, Bouwman FH, Kok A, van Elk EJ, et al. Amyloid-beta(1-42), total tau, and phosphorylated tau as cerebrospinal fluid biomarkers for the diagnosis of Alzheimer disease. Clin Chem 2010 Feb;56(2):248-253 [FREE Full text] [doi: 10.1373/clinchem.2009.130518] [Medline: 19833838]
31. Scheltens P, Launer LJ, Barkhof F, Weinstein HC, van Gool WA. Visual assessment of medial temporal lobe atrophy on magnetic resonance imaging: interobserver reliability. J Neurol 1995 Sep;242(9):557-560. [Medline: 8551316]
32. de BJ, Portegies MP, Leemans A, Biessels GJ, Kappelle LJ, Viergever MA. A comparison of MR based segmentation methods for measuring brain atrophy progression. Neuroimage 2011 Jan 15;54(2):760-768. [doi: 10.1016/j.neuroimage.2010.09.060] [Medline: 20888923]
33. Mendrik AM, Vincken KL, Kuijf HJ, Breeuwer M, Bouvy WH, de Bresser BJ, et al. MRBrainS Challenge: Online Evaluation Framework for Brain Image Segmentation in 3T MRI Scans. Comput Intell Neurosci 2015;2015:813696 [FREE Full text] [doi: 10.1155/2015/813696] [Medline: 26759553]
34. Román GC, Tatemichi TK, Erkinjuntti T, Cummings JL, Masdeu JC, Garcia JH, et al. Vascular dementia: diagnostic criteria for research studies. Report of the NINDS-AIREN International Workshop. Neurology 1993 Feb;43(2):250-260. [Medline: 8094895]
35. McKeith I, Dickson D, Lowe J, Emre M, O'Brien J, Feldman H, et al. Diagnosis and management of dementia with Lewy bodies: third report of the DLB Consortium. Neurology 2005 Dec 27;65(12):1863-1872. [Medline: 16237129]
36. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 1984 Jul;34(7):939-944. [Medline: 6610841]
37. Rascovsky K, Hodges JR, Knopman D, Mendez MF, Kramer JH, Neuhaus J, et al. Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. Brain 2011 Sep;134(Pt 9):2456-2477 [FREE Full text] [doi: 10.1093/brain/awr179] [Medline: 21810890]
38. Neary D, Snowden JS, Gustafson L, Passant U, Stuss D, Black S, et al. Frontotemporal lobar degeneration: a consensus on clinical diagnostic criteria. Neurology 1998 Dec;51(6):1546-1554. [Medline: 9855500]
39. Wadia PM, Lang AE. The many faces of corticobasal degeneration. Parkinsonism Relat Disord 2007;13 Suppl 3:S336-S340. [doi: 10.1016/S1353-8020(08)70027-0] [Medline: 18267261]
40. Litvan I, Agid Y, Calne D, Campbell G, Dubois B, Duvoisin R, et al. Clinical research criteria for the diagnosis of progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome): report of the NINDS-SPSP international workshop. Neurology 1996 Jul;47(1):1-9. [Medline: 8710059]
41. Dooneief G, Marder K, Tang M, Stern Y. The Clinical Dementia Rating scale: community-based validation of “profound' and ”terminal' stages. Neurology 1996 Jun;46(6):1746-1749. [Medline: 8649584]
42. Inzitari D, Pracucci G, Poggesi A, Carlucci G, Barkhof F, Chabriat H, et al. Changes in white matter as determinant of global functional decline in older independent outpatients: three year follow-up of LADIS (leukoaraiosis and disability) study cohort. BMJ 2009 Jul 06;339:b2477-b2477. [doi: 10.1136/bmj.b2477] [Medline: 19581317]
43. Sachdev P, Kalaria R, O'Brien J, Skoog I, Alladi S, Black SE, Internationlal Society for Vascular BehavioralCognitive Disorders. Diagnostic criteria for vascular cognitive disorders: a VASCOG statement. Alzheimer Dis Assoc Disord 2014;28(3):206-218 [FREE Full text] [doi: 10.1097/WAD.0000000000000034] [Medline: 24632990]

Abbreviations

AHA/ASA: American Heart Association/American Stroke Association
APOE: apolipoprotein E
Aβ42: amyloid B 1-42
BMI: body mass index
CAMCOG: Cognitive and Self-Contained Part of the Cambridge Examination for Mental Disorders of the Elderly (CAMDEX)
CDR: Clinical Dementia Rating
CSF: cerebrospinal fluid
DAD: Disability Assessment for Dementia
DSCT: Digit Symbol-Coding Test
FLAIR: fluid-attenuated inversion recovery
GDS: Geriatric Depression Scale
LDST: Letter Digit Substitution Test
MCI: mild cognitive impairment
MMSE: Mini-Mental State Examination
MTA: medial temporal lobe atrophy
NOCI: no cognitive impairment
NPI: Neuropsychiatric Inventory
p-tau: total tau phosphorylated at threonine 181
RAVLT: Rey Auditory Verbal Learning Test
STRIVE: Standards for Reporting Vascular Changes on Neuroimaging
SWI: susceptibility-weighted imaging
TMT: trail making test
TR/TE/TI: Repetition Time/Echo Time/Inversion Time
TRACE-VCI: Utrecht Amsterdam clinical features and prognosis in vascular cognitive impairment
UMCU: University Medical Centre Utrecht
VasCog: International Society of Vascular Behavioural and Cognitive Disorders
VAT: Visual Association Test
VCI: vascular cognitive impairment
VUMC: VU (Vrije (Free)) University Medical Centre
WAIS-III: Wechsler Adult Intelligence Scale – 3rd edition
WMH: white matter hyperintensities

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Original Paper

Comparing Crowdsourcing and Friendsourcing: A Social Media-Based Feasibility Study to Support Alzheimer Disease Caregivers

Daniel Robert Bateman[1,2,3,4], MD; Erin Brady[1,3,5], MSc, PhD; David Wilkerson[1,3,6], LICSW, PhD; Eun-Hye Yi[1,3,6], MSW; Yamini Karanam[5], BS; Christopher M Callahan[1,3,4,7], MD

[1]Indiana University Center for Aging Research, Indianapolis, IN, United States

[2]Department of Psychiatry, Indiana University School of Medicine, Indianapolis, IN, United States

[3]Regenstrief Institute, Indianapolis, IN, United States

[4]Indiana Alzheimer Disease Center, Indianapolis, IN, United States

[5]Department of Human-Centered Computing, School of Informatics and Computing, Indiana University Purdue University Indianapolis, Indianapolis, IN, United States

[6]School of Social Work, Indiana University, Indianapolis, IN, United States

[7]Department of Medicine, Indiana University School of Medicine, Indianapolis, IN, United States

Corresponding Author:
Daniel Robert Bateman, MD
Indiana University Center for Aging Research
1101 West Tenth Street
Indianapolis, IN, 46202
United States
Phone: 1 317 274 9334
Fax: 1 317 274 9302
Email: darbate@iupui.edu

Abstract

Background: In the United States, over 15 million informal caregivers provide unpaid care to people with Alzheimer disease (AD). Compared with others in their age group, AD caregivers have higher rates of stress, and medical and psychiatric illnesses. Psychosocial interventions improve the health of caregivers. However, constraints of time, distance, and availability inhibit the use of these services. Newer online technologies, such as social media, online groups, friendsourcing, and crowdsourcing, present alternative methods of delivering support. However, limited work has been done in this area with caregivers.

Objective: The primary aims of this study were to determine (1) the feasibility of innovating peer support group work delivered through social media with friendsourcing, (2) whether the intervention provides an acceptable method for AD caregivers to obtain support, and (3) whether caregiver outcomes were affected by the intervention. A Facebook app provided support to AD caregivers through collecting friendsourced answers to caregiver questions from participants' social networks. The study's secondary aim was to descriptively compare friendsourced answers versus crowdsourced answers.

Methods: We recruited AD caregivers online to participate in a 6-week-long asynchronous, online, closed group on Facebook, where caregivers received support through moderator prompts, group member interactions, and friendsourced answers to caregiver questions. We surveyed and interviewed participants before and after the online group to assess their needs, views on technology, and experience with the intervention. Caregiver questions were pushed automatically to the participants' Facebook News Feed, allowing participants' Facebook friends to see and post answers to the caregiver questions (Friendsourced answers). Of these caregiver questions, 2 were pushed to crowdsource workers through the Amazon Mechanical Turk platform. We descriptively compared characteristics of these crowdsourced answers with the friendsourced answers.

Results: In total, 6 AD caregivers completed the initial online survey and semistructured telephone interview. Of these, 4 AD caregivers agreed to participate in the online Facebook closed group activity portion of the study. Friendsourcing and crowdsourcing answers to caregiver questions had similar rates of acceptability as rated by content experts: 90% (27/30) and 100% (45/45), respectively. Rates of emotional support and informational support for both groups of answers appeared to trend with the type of support emphasized in the caregiver question (emotional vs informational support question). Friendsourced answers included more shared experiences (20/30, 67%) than did crowdsourced answers (4/45, 9%).

Conclusions: We found an asynchronous, online, closed group on Facebook to be generally acceptable as a means to deliver support to caregivers of people with AD. This pilot is too small to make judgments on effectiveness; however, results trended toward an improvement in caregivers' self-efficacy, sense of support, and perceived stress, but these results were not statistically significant. Both friendsourced and crowdsourced answers may be an acceptable way to provide informational and emotional support to caregivers of people with AD.

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KEYWORDS

Alzheimer disease; Alzheimer disease and related dementias; caregivers; mobile health; social media; crowdsourcing; friendsourcing; emotional support; informational support; online support

Introduction

Studies predict that the worldwide prevalence of dementia will reach 48.1 million people by the year 2020 [1]. Alzheimer disease (AD) accounts for the majority of cases of dementia in the United States [2]. Unlike for many other diseases, to date there are no disease-modifying agents to slow down or stop the progression of AD. Until disease-modifying agents become available, psychosocial and psychoeducational interventions remain the intervention of choice for addressing treatment needs of patients and caregivers. Informal, unpaid caregivers deliver the majority of care received by people with AD [3]. Estimates for 2013 put the value of this informal, unpaid care for people with AD and other dementias in the United States at US $470 billion [3]. Fiscal estimates do not account for the mental and physical health burdens endured by many AD caregivers. Besides the inherent detriment to caregivers, higher caregiver burden and lower caregiver subjective health ratings adversely affect patients with AD. Higher caregiver burden results in earlier nursing home placement, while lower caregiver subjective health is associated with higher mortality in people with AD [4]. Prior work showed that AD caregivers receive health benefits from psychosocial and psychoeducational interventions [5]. Yet many caregivers' needs remain unmet due to multiple barriers, including time and distance. Social media offers an opportunity to provide support to AD caregivers while overcoming some of these barriers [5].

Caregivers have a higher incidence of mental illness and benefit from emotional support. These mental illnesses include anxiety [6-8], depression [6,9-15], poor sleep quality [7,8], and substance abuse or dependence [16]. Caregiving also affects the work force, with caregivers displaying greater absenteeism [6,7], higher rates of poor physical health [17-19], and higher mortality [20,21]. Studies show that strategies of problem-focused coping, acceptance, and social-emotional support improve caregiver mental health and depression [3,22-26].

Caregivers receive emotional and informational support from many sources, but these existing sources have limitations. In-person social support groups can meet caregiver support needs including emotional support and self-appraisal [27], but they present limitations based on the logistical issues of scheduling, traveling, and finding alternative supervision for the person with dementia while the caregiver is absent. Membership in online health communities can address logistical barriers to service utilization, and caregivers often seek emotional and informational support from their peers [28]. However, cautions about the reliability of health care information being shared [29], the tendency of participants to lurk by browsing rather than contributing content [30,31], and participation inequalities [32] point to limitations that interfere with the ability of online communities to support caregivers in the process of coping.

Other systems may provide individualized support for the caregiver, supplementing the benefits of traditional forums. However, any technological system designed to provide just-in-time personalized support to caregivers requires a large number of people who are online and available to respond to their questions. Systems that connect a caregiver to a clinician or trained social worker are unlikely to scale well, due to the limited size of the clinician population. For this study, we investigated *crowdsourcing* and *friendsourcing* as alternatives to soliciting appropriate and supportive feedback to questions from caregivers.

Crowdsourcing is a way to leverage remote workers to perform small tasks, either for financial compensation or on a voluntary basis [33]. In crowdsourced systems, a task is broken up into parts and distributed to remote workers, who can complete the sections in parallel or build on the work of others. The answers provided by these workers can be aggregated and used to create systems that leverage human intelligence in novel ways. Crowdsourcing systems have been used to provide emotional support to individuals by collecting empathetic responses or cognitive reappraisals of stressful situations [34]. While online forums are used by many to seek information, crowdsourcing can be a more efficient and reliable way of seeking information. Drawbacks of traditional crowdsourcing include financial costs and variable quality of answers, depending on the expertise and experience of the crowd workers.

Friendsourcing is a paradigm that combines social media information seeking with crowdsourcing [35]. In friendsourcing, individuals use their friends and contacts online as a resource for crowdsourcing information or help. While friendsourcing can be used to identify specific information that only your network would know [35], as people gain stronger trust in the information their friends or families provide, they often leverage these social networks to seek information that might be available to them in other places [36]. Prior work has shown that as many as 50% of social media users have friendsourced a question to their online networks before [36], and that social media can have significant impacts on health-related behavior change and well-being [37,38]. There are often benefits to providing this

information as well. People answering questions have improved self-efficacy, build a sense of reciprocity with the question asker, and appreciate the opportunity to show off their expertise [36,39].

Online peer support activities can help AD caregivers reduce the stress of caregiving and enhance hands-on knowledge and self-efficacy. A common model of online peer support involves the use of online discussion forums. Drawbacks of the online discussion forum model include low user content contribution and limited efficiency for accessing correct information.

We designed this pilot study to explore alternative online methods to address caregiver needs through online peer support. This research conducted by an interdisciplinary team aimed to overcome previously mentioned drawbacks by adapting friendsourcing, within a closed Facebook group. To our knowledge, our work is the first to use friendsourcing to provide support to AD caregivers. The underpinning theory of this intervention is that social support moderates caregiver burden and stress. We hypothesized that the study intervention would be acceptable to AD caregivers as a method for obtaining online support, that friendsourced and crowdsourced answers to caregiver questions would be of high-quality content, and that friendsourced answers would have higher rates of shared experiences in comparison with crowdsourced answers.

The contributions of this study include (1) an assessment of the feasibility of online support delivery to AD caregivers through social media and friendsourcing, (2) an evaluation and comparison of friendsourced and crowdsourced answers to caregiver questions in terms of content quality, acceptability, and rates of shared experiences, and (3) suggestions for future research directions for online support delivery to AD caregivers through social media.

Methods

Study Participants and Recruitment

Potential participants were nonpaid family caregivers of people with AD. We distributed a recruiting advertisement across the United States through organizational webpages, including the Alzheimer's Association webpage and newsletter, Indiana University Purdue University Indianapolis's online newsletter *News at IUPUI*, radio interviews, and social media, including Twitter (Twitter, Inc, San Francisco, CA, USA) and Facebook (Facebook, Inc, Menlo Park, CA, USA), from July through September 2016. Potential participants gained access to the study through the study website. The website provided study information, inclusion and exclusion criteria, links to the online survey, and a PDF of the informed consent form. This study was approved by the Indiana University Institutional Review Board (# 160317338) through expedited review.

Study inclusion criteria for participation were as follows: the participant must (1) be 18 years or older, (2) live in the United States, (3) be able to read, comprehend, and write in English, (4) be the caregiver of an individual with AD who lives at home with the caregiver, (5) provide at least 8 hours of caregiving for the person with AD per week, (6) have a Facebook account with at least 40 Facebook friends, (7) have posted or commented on Facebook on average at least twice per week for the past month, (8) have ready access to the Internet, and (9) agree to give his or her informed consent to participate in this research. Exclusion criteria were a psychiatric hospitalization or suicide attempt in the past year. We chose age 18 years as the cutoff so that all participants were legal adults. The requirement of 40 Facebook friends was arbitrarily chosen as a cutoff to indicate the participant had a preexisting online social network before joining the study.

Design

This study used a pretest-posttest design with mixed methods. We sequentially allotted participating nonpaid family caregivers of people with AD to 3 closed Facebook groups to receive the intervention over the course of 6 weeks (September 29, 2016 to October 10, 2016). As this trial is ongoing, the results of this paper are restricted to the first group of study participants. The study was composed of 4 parts: (1) the preintervention portion, where participants completed consent, an online survey, a semistructured interview, and installation of the study Facebook app; (2) the 6-week intervention; (3) the postintervention portion, where participants were asked to complete a postintervention survey, semistructured interview, and optional reflection group; and (4) the follow-up portion, where participants were asked to complete an online role transformation survey 6 weeks after completion of the intervention.

All participants provided written informed consent through the online survey page. Once participants met screening criteria and consented to the study online, they could proceed to the online survey preintervention portion of the study. The survey included questions on demographic information and required completion of 7 standardized scales (described below). Once we identified an applicant's completion of the survey, one of the research team members conducted a semistructured telephone interview and guided the participant in installation of the study app.

The intervention comprised 2 major components: interaction within a closed Facebook online support group and posting of anonymous questions about caregiving to each participant's Facebook News Feed through the study app. Participants interacted with other group members within the private Facebook online support group by posting and responding to each other's comments. We facilitated group introductions and discussion through weekly prompts. These prompts requested participants to discuss emotional or informational support questions that the group chose to share with their social network (Facebook friends). We observed and moderated postings and participation. Moderation included sending reminder prompts to post information for participants who did not respond to the initial prompts to post information, answering technical and study activity questions, and monitoring for comments that could cause harm to the participants.

Through the study app, selected questions were automatically posted to the Facebook News Feed of each participant so that his or her Facebook friends could review and post responses to the caregiver questions (Figure 1). These answers from Facebook friends were then reposted into the private Facebook

group for group members to read as a way to leverage their impact on peer social support.

By posting each question to the News Feed of each caregiver, we were able to expand the number of people available to provide support at any point. Figure 2 shows how the support network size is increased by using friends from multiple networks as potential question answerers. Prior work on social microvolunteering has shown that this use of multiple networks can approximate the speed of crowdsourcing in collecting answers to questions [39].

After finishing the 6-week intervention, participants were asked to complete the postsurvey and semistructured telephone interview. They were then offered the opportunity to participate in an optional reflection group and role transformation survey. Participants received compensation for their time and effort in the form of electronic gift cards.

Figure 1. An example of a question from the caregiving group, which is automatically posted to the Facebook News Feed of each caregiver after screening by the research team.

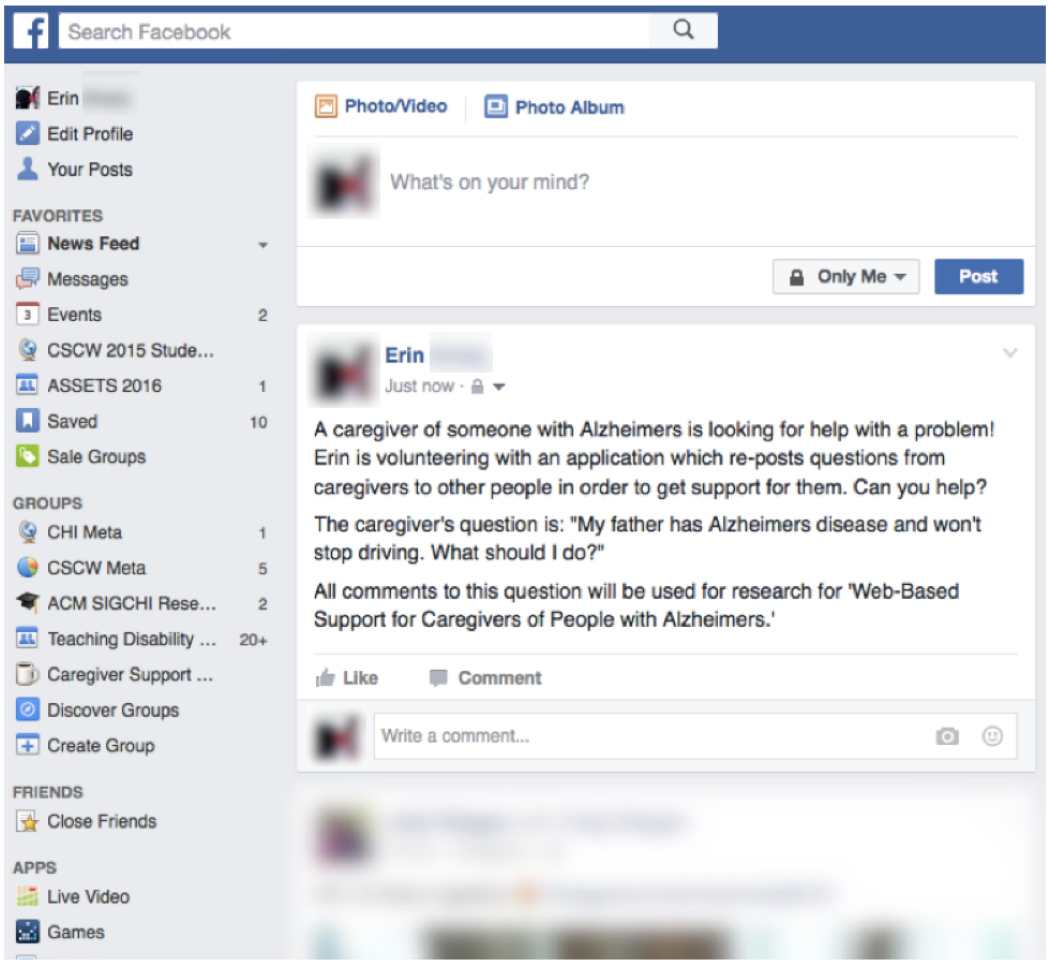


Figure 2. Leveraging multiple social networks for support increases the number of people available to answer questions.

Data and Measures

We collected both quantitative and qualitative data at multiple time periods during the study. We gathered demographic variables, including age, sex, living arrangement, level of education, employment status, income, type of residential area, and relationship with the care recipient, through the preintervention survey. We also gathered qualitative data from preintervention and postintervention interviews and follow-up reflection group interviews. Additionally, comments were collected from the automatic posts made in each participant's Facebook News Feed. These comments included those made by the participants and those made by their social network (Facebook friends) in response to posted caregiver questions.

The preintervention and postintervention online surveys included 7 standardized self-reported caregiving-related instruments: the Zarit Burden Interview Short Form (ZBI-12) [40], the Perceived Stress Scale-14 (PSS-14) [41], the Revised Scale for Caregiving Self-Efficacy [42], the Medical Outcomes Study (MOS) Social Support Survey [43], the Dementia Severity Rating Scale [44], the Neuropsychiatric Inventory Questionnaire [45], and the Facebook Intensity Scale (FBI) [46]. Below we describe 3 of the scales that capture caregiver needs, social support, and views on technology.

The ZBI-12 [40] measures caregivers' perceived burdens of their caregiving roles. The measurement consists of 12 items in 2 main domains: personal strain and role strain. Each question asks about the frequency at which a caregiver experiences certain types of caregiving difficulties. It is scored in a 5-point Likert-type scale from 0 (never) to 4 (nearly always).

The MOS Social Support Survey measures the availability and frequency of different types of support [43]. The scale is composed of 19 items with 3 subsections—8 emotional and informational support sections, 4 tangible support sections, and 6 affectionate support sections—and 1 additional item. It is scored on a 5-point Likert scale from 1 (none of the time) to 5 (all the time).

The FBI is composed of 8 items about the level of familiarity with Facebook: 6 items were scored using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) [46], and 2 open-ended questions assessed the user's Facebook behavior regarding the total number of Facebook friends and the average hours per day of availability to use Facebook.

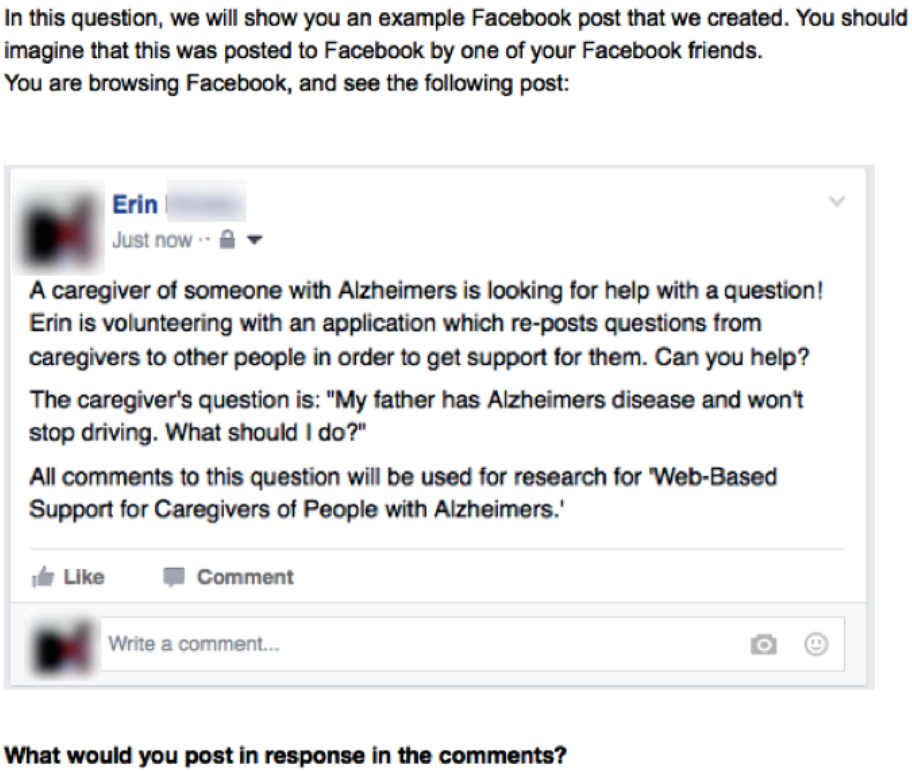
Crowdsourcing Using Amazon Mechanical Turk

Through a separate study approved by the Indiana University Institutional Review Board (# 1609570045), we posted 2 of our caregiver questions to the Amazon Mechanical Turk (Amazon.com, Inc, Seattle, WA, USA). Amazon Mechanical Turk is a traditional crowdsourcing platform where a vast pool of workers can select tasks to complete for small payments [33]. Mechanical Turk is frequently used as an input to academic crowdsourcing systems, including those supporting emotional health [34] and those evaluating health literacy [47].

We posted our questions on Mechanical Turk with the goal of comparing these answers with the answers provided by our caregivers' online social networks. We recruited Masters-level Turkers, who have met specific qualifications indicating their experience level with using the platform. Workers who accepted the task on Mechanical Turk were presented with an example question, shown in the same Facebook post format as was posted to the caregivers' News Feed (Figure 3). They were asked how they would respond in the comments to that post.

The workers were paid US $3 for their response. While this is a higher payment rate than in many other Amazon Mechanical Turk studies [48], it is in line with worker expectations of payment on Amazon Mechanical Turk as a labor marketplace [49].

Figure 3. An example of a question posted on Amazon Mechanical Turk.



Data Analysis

Survey results helped characterize participants through measures of caregiving stress, self-efficacy, familiarity with Facebook, care recipient symptoms, and illness severity. We audio recorded and transcribed participant interviews and then conducted a deductive thematic analysis of these transcriptions focused on participants' access to support [50]. Interviews were open coded and themes were identified across participants and reported via prevalence.

We evaluated the Facebook friend (friendsourcing) answers to caregiving questions. Answers were reviewed by 2 content experts (DRB and DW) for acceptability, shared experiences, emotional support, and informational support. Agreement was obtained through a process of adjudication. Answers were described qualitatively. We used the same rating process for the crowdsourced answers obtained through Amazon Mechanical Turk. Acceptability was defined as an answer that, without further information or advice, would be unlikely to cause harm to a caregiver and care recipient, if it were to be read. We used definitions for "emotional support messages" and "informational support messages" from Wang et al [51]. Emotional support messages provide or show understanding, encouragement, affirmation, sympathy, or caring [51]. Informational support messages deliver advice, referrals, or knowledge [51].

Results

Participants

A total of 12 potential participants accessed the online study survey. Of these, 6 participants completed the online survey and semistructured telephone interview, and 4 of these 6 agreed to participate in the group activity portion of the study. Only 1 of the 6, P6, declined to participate, because she felt she did not need any extra support. Her MOS Social Support Survey results were consistent with this reasoning. Another participant, P5, declined, citing limited time as a result of caregiving obligations as the main reason for nonparticipation. She estimated her hours of caregiving at 148 hours per week, 128 hours longer than the next closest participant (Table 1). Participants' ages ranged from 34 to 74 years, with a mean age of 58 years. Of the 6 participants, 5 had completed some college, with 2 participants having obtained advanced degrees. The hours of caregiving provided per week ranged from 16 to 148, with a mode of 20. Duration of caregiving ranged from 7 to 36 months, with a mean of 20 months. Half (n=3) of the caregivers were either a spouse or partner to the care recipient. All 5 of the care recipients (people with AD) were female. Participant ZBI-12 scores ranged from 12 to 30 (range 0-48) with a mean of 21.83 (SD 5.81) (Table 2).

Table 1. Demographic characteristics of persons with Alzheimer disease (AD) and their caregivers (study participants).

Characteristics	Participant					
	P1	P2	P3	P4	P5[a]	P6[a]
Caregivers						
Sex	Male	Male	Female	Male	Female	Female
Race/ethnicity	White	African American	White	White	White	Asian American
Education	4-year college	4-year college	Master's degree	2-year college	High school	Master's degree
Employment status	Retired	Retired	Full-time	Part-time	Retired	Full-time
Marital status	Married	Not married	Married	Married	Divorced	Married
Living arrangement	Living together	Living together	Living together	Living together	Living alone	Living together
Living area	Suburban	Metro	Urban	Suburban	Suburban	Metro
Self-reported health status	Good	Very good	Good	Good	Good	Good
Age (years)	74	61	34	60	73	46
Caregiving						
Duration of caregiving (months)	24	24	7	9	36	N/A[b]
Caring time (hours/week)	20	N/A	16	16	148	N/A
Person with AD characteristics						
Relation to caregiver	Wife	Partner	Mother	Wife	Mother	N/A
Age (years)	74	55	65	65	93	N/A
Sex	Female	Female	Female	Female	Female	N/A
Race/ethnicity	White	White	White	White	White	N/A

[a]Did not participate in the group portion of the study.

[b]N/A: not available.

Table 2. Caregiver burden, social support, and technology use: baseline scores.

Measure	Participant						Mean (SD) score	
	P1	P2	P3	P4	P5[a]	P6[a]	n=6 (P1–P6)	n=4 (P1–P4)
Zarit Burden Interview Short Form (5-point scale; 12 items; range 0-48)	22	22	24	21	30	12	21.83 (5.81)	22.25 (1.26)
Medical Outcomes Study Social Support Survey								
Emotional and informational support (8 items)	8	8	21	23	32	33		
Tangible support (4 items)	16	4	12	12	10	16		
Affectionate support (3 items)	12	15	15	12	11	12		
Positive social interaction (3 items)	9	15	15	12	7	12		
Additional item (1 item)	3	4	4	3	3	4		
Total (5-point scale; 19 items; range 19-95)	48	46	67	62	63	77	60.50 (11.74)	55.75 (10.34)
Facebook Intensity Scale								
Familiarity with Facebook (5-point scale; 6 items; range 6-30	12	6	7	23	6	16	11.67 (6.83)	12.00 (7.79)
No. in Facebook network (approximate)	80	900	1000	40	400	100	420 (431.18)	505 (515.72)
Available time to use Facebook (min/day)	20	60	180	0	120	15	65.83 (70.74)	65.00 (80.62)

[a]Did not participate in the group portion of the study.

Deductive Thematic Analysis

Limitations of Current Support Resources

All 4 participants in the group portion of the study had access to some type of support for their caregiving, but these resources were limited in significant ways. All of our participants reported insufficient access to in-person support.

In-Person Support

Family was the most commonly referenced source of support, with all 4 participants describing family members who had provided them with emotional support. A total of 3 participants were geographically isolated from most of their family members, meaning that the burden of caregiving fell primarily on them. They also had to explicitly contact family members for emotional support. The caregivers were often the only family members with enough contextual information to make health decisions for their care recipient, meaning they could not rely on family members for informational support. Primary caregivers often instead provided support to those family members:

> *I think a lot of it is, I have a lot of family members that are in [state] that are not medical and sometimes don't understand what is going on with her. They ask me a lot of questions...I just want to keep her comfortable and they don't always understand that. I think that's hard for me to justify all of my actions with her.* [P3]

Many participants experienced a change in their ability to leave their home as a result of their caregiving, which meant they had less access to social or emotional support from friends in workplace or recreational settings. Indeed, 2 participants had cut back or left their jobs to focus on caregiving full-time, while others gave up existing hobbies or social activities, so as not to leave their care recipient alone. These changes may have led to a smaller network of support immediately available to them.

All 4 caregivers relied on their loved one's doctors as a primary resource for informational support.

The doctors observed macro-level changes in the patients' behavior and health, rather than day-to-day issues. Support from physicians was infrequently available. For example, P4 specified that he interacted with his wife's doctor only once every 3 months. Some caregivers also used medical professionals as a source of emotional support, and 2 participants sought formal emotional support through therapy. As with informational support, professional emotional support was highly valued by the caregivers who accessed it. However, long intervals occurred between visits, and caregivers expressed a wish to have access to additional emotional support.

Online Support

To join our study, participants were required to have an active Facebook account with at least 40 friends, meaning that our participants were likely to have significant technological experience. All participants reported having both computers and smartphones through which they accessed the Internet. Despite this baseline level of technology and social media use, we found a variety of use patterns and technology acceptance among our participants.

Two caregivers, P1 and P4, had small networks on Facebook (80 and 40 estimated friends, respectively; Table 2). Both primarily used the sites to catch up with friends and family. While P4 had not previously used Facebook to access emotional support, P1 shared how his family used Facebook to encourage him during his caregiving:

> *One day my daughter posted on Facebook what a great job I was doing taking care of her mom and so on.* [P1]

The other 2 participants, P2 and P3, had large networks on Facebook (900 and 1000 estimated friends, respectively; Table 2) and used the site both to socialize and to access news or information about AD. P3 described how she valued Facebook as a resource for her friendships and for learning:

> *I look up sports there [on Facebook] and I follow three different Alzheimer's things. I try to mix work there so that way I will look at it. It's like a one-stop news place for me. Equal half for friends and information.* [P3]

While all participants except P4 used other social network sites, like Twitter or Pinterest, all participants reported that Facebook was the site that they used with the highest frequency.

Caregivers used a variety of online resources to access informational support. Some of that information was acquired passively, by following or subscribing to updates from AD organizations via Facebook or email. Others sought information actively by researching specific informational questions. While participants used online forums to research information support questions, none had posted on online forums or discussion groups related to caregiving themselves. P4 reported that he had browsed one of these forums for information, but had not yet posted his own questions:

> *I read them. I have thought of posting on it. I'm still new on it. So I'm kind of reading other experiences, because there is so much good information in there. For example, a lady posted that her dad keeps wandering away from the house or another posts about how their mom does not sleep at night. How to handle that. I read that to see their responses. It's been very helpful. Yes, reading about other people's experiences [is] very helpful.* [P4]

> *I'm not sure. I tend to be a private person. I would not be comfortable opening up with people [I] don't know with the exception of Facebook. There is this thing about the Internet where I may never meet that person.* [P1]

Our participants' responses indicate a need for additional support, as well as a familiarity with Facebook that might make it a more appealing source of support than anonymous forums or crowdsourcing platforms.

Activity During Facebook Online Support Group

During the online Facebook group portion of the study, we posted 4 online prompts (Table 3). There were a total of 12

replies (postings) by group members in response to our prompts. The group participants had 20 spontaneous voluntary posts or replies to other members of the group.

Table 3. Summary of online activity for the whole group and by individual participants.

Type of activity	Group totals	Individual participants			
		P1	P2	P3	P4
Group activities					
No. of group participants (total)	4				
No. of posted questions by the research team (total)	4				
No. of activities in the group (total)	32				
Replies and posts responding to requests from the research team	12				
Unprompted postings and replies from group members	20				
Facebook crowds activities					
No. of questions pushed to Facebook friends (total)	3				
No. of answers from Facebook friends (total)	44	6	19	11	11
No. of answers from Facebook friends (mean)		2	6.33	3.67	3.67
No. of answers to first question		1	11	6	2
No. of answers to second question		2	4	1	5
No. of answers to third question		3	4	4	4
Reported no. of Facebook friends		80	900	1000	40

Friendsourcing Results

We pushed 3 caregiver questions to the participants' Facebook News Feed, allowing participants' Facebook friends to see and reply to the caregiver questions. The total number of Facebook friend responses was 44 (Table 3). The range of total number of Facebook friend responses per participant varied between 6 and 19.

Friendsourcing and crowdsourcing answers had high and similar rates of acceptability, as judged by content experts: 90% (27/30) and 100% (45/45), respectively (Table 4). This study lacked the power to draw quantitative conclusions from these data. Friendsourced answers contain shared experiences at a higher rate than Amazon Mechanical Turk answers: 67% (20/30) and 9% (4/45), respectively. Rates of emotional support and informational support messages present in friendsourcing and crowdsourcing answers were similar, and appeared more dependent on the type of question asked rather than the group answering the question.

Table 4. Caregiver questions answered through friendsourcing and crowdsourcing (Amazon Mechanical Turk).

Type of answers	Q1[a]	Q2[b]	Total, n (%)
Friendsourcing answers			
Total number of answers	19	11	
Acceptable answers, n (%)	16 (84)	11 (100)	27/30 (90)
Shared experiences, n (%)	12 (63)	8 (73)	20/30 (67)
Combined (informational + emotional support), n (%)	5 (26)	5 (45)	
Informational support, n (%)	19 (100)	7 (63)	
Emotional support, n (%)	5 (26)	9 (82)	
Crowdsourcing answers			
Total number of answers	20	25	
Acceptable answers, n (%)	20 (100)	25 (100)	45/45 (100)
Shared experiences, n (%)	3 (15)	1 (4)	4/45 (9)
Combined (informational + emotional support), n (%)	6 (30)	15 (60)	
Informational support, n (%)	19 (95)	21 (84)	
Emotional support, n (%)	7 (35)	19 (76)	

[a]Q1 was “My father has Alzheimer’s disease and won’t stop driving. What should I do?”

[b]Q2 was “It is very hard for me to share my personal feelings about my struggles with my mother’s Alzheimer’s so when people ask about how my mother’s doing, I either minimize her symptoms or just unload on them. How can I explore my own feelings better without having to talk to someone so that I can better communicate about my mother’s battle with Alzheimer’s? I would love to be an advocate for Alzheimer’s awareness without turning people off to talking about it.”

Effects of the Intervention

Our small sample prevented the use of parametric statistics; thus, we used Wilcoxon signed rank tests to compare preintervention and postintervention measures. This nonparametric method considers scores as ranks to measure changes between 2 periods. We calculated both medians and means. None of the pretest-posttest comparisons showed a statistically significant difference (Table 5). However, caregiver burden (measured by ZBI-12) showed a trend toward improvement in overall caregiver burden. There were trends toward an increase in emotional and informational support, tangible support, and total social support, but these results were not statistically significant. FBI showed a near doubling of the level of familiarity with Facebook. The number of Facebook friends and time available to use Facebook also increased. The median and mean scores of PSS-14 frequencies (having emotional problems in the last month) decreased, although the change was not statistically significant. The Revised Scale for Caregiving Self-Efficacy, a measure of confidence regarding caring activities, showed a trend toward improved confidence.

Table 5. Comparisons of preintervention and postintervention caregiver data.

Scale	Pre-scores (A), median (mean) (n=6)	Pre-scores (B), median (mean) (n=4)	Post-scores (C), median (mean) (n=4)	Difference (C–B)	
				z Score	*P* value
Zarit Burden Interview Short Form	22.00 (21.83)	22 (22.25)	18.00 (18.75)	–1.29	.20
Medical Outcomes Study Social Support Survey					
Emotional and informational support	22 (20.83)	14.5 (15)	22.5 (21.25)	–1.63	.10
Tangible support	12 (11.67)	12 (11)	15 (13.5)	–1.07	.29
Affectionate support	12 (12.83)	13.5 (13.5)	12 (10)	–1.07	.29
Positive social interaction	12 (11.67)	13.5 (12.75)	9 (9)	–1.13	.26
Additional item	3.5 (3.5)	3.5 (3.5)	3 (3)	–0.54	.59
Total scores	62.5 (60.5)	55 (55.75)	62 (56.75)	–0.37	.72
Perceived Stress Scale-14	31 (31.67)	31 (31.25)	22.5 (22.75)	–1.83	.07
Revised Scale for Caregiving Self-Efficacy					
Self-efficacy for obtaining respite	250 (213.33)	250 (197.5)	230 (215)	–0.54	.59
Self-efficacy for responding to disruptive patient behaviors	445 (445)	440 (440)	430 (397.5)	–0.92	.36
Self-efficacy for controlling upsetting thoughts about caregiving	335 (335)	340 (315)	345 (342.5)	–0.55	.58
Total scores	975 (993.33)	975 (952.5)	1040 (955)	0.00	>.99
Facebook Intensity Scale					
Familiarity with Facebook	9.5 (11.67)	9.5 (12)	17.55 (21.55)	–1.83	.07
Approximate no. in Facebook network	250 (420)	490 (505)	620 (585)	–1.60	.11
Time to use Facebook (min/day)	40 (65.83)	40 (65)	60 (53.75)	0.00	>.99

Discussion

Feasibility of the Intervention

We evaluated the feasibility of soliciting acceptable answers to informational and emotional questions through the Facebook News Feeds of caregivers. Based on participation and qualitative feedback from participants, our study found friendsourcing to be a feasible Web-based intervention for AD caregivers. Our online support group and app successfully facilitated "pushing" caregiver questions to the Facebook News Feed of participants, allowing their Facebook friends to see and answer these questions. We compared friendsourcing versus crowdsourcing answers to caregiver questions. Both provided acceptable answers as judged by content experts, as well as similar rates of informational and emotional support messages. However, we consistently found that friendsourcing provided significantly higher rates of shared experiences as compared with crowdsourcing.

While this approach was feasible to collect acceptable answers in the short term, sustainability is an important concern for social-microvolunteering systems [39]. For this system to succeed in a full deployment, it would require a reliable set of answerers, and the quality of responses would need to be maintained despite the potential for answerer fatigue. This needs to be explored further in future studies.

Central to obtaining support and responding to demands for coping is the shared experience of group membership. Shared experience has been identified as the basis for engagement in peer support groups, because peers can provide a level of support that may be unavailable through natural supports like family and friends [52]. We designed our Web-based support intervention to include friendsourcing rather than crowdsourcing, for reasons of greater financial affordability and greater potential for shared experiences.

Limitations

Low sample size was a drawback of this study and limits the generalizability of our results. Our study was too small to determine the effectiveness of the intervention on caregiver outcomes. However, we noted that data trended toward an improvement in caregiver self-efficacy, sense of support, and perceived stress.

The generalizability of the populations who provided the friendsourced and crowdsourced answers may also be limited. Members of crowdsourcing platforms, specifically those on Mechanical Turk, are likely to be more educated than the average US population [53]. Any of a user's Facebook friends are most likely to be the same age as the user, demonstrating the homophily of networks around age [54]. As a result, a caregiver's network may be composed of more adults with an age demographic more likely to deal with AD in their spouses or parents. Users of Mechanical Turk have traditionally skewed younger [55,56], and recent estimates found that 88% of workers were 49 years or younger [55]. Thus, these workers may not have as much experience with AD.

The duration of this study was relatively brief at 6 weeks. It is unclear whether a longer trial of an online support group and

friendsourced answers would provide a greater benefit for AD caregivers. However, Rains and Young's 2009 meta-analysis of peer support group outcomes suggest a longer trial would provide greater benefits to caregivers [57].

Friendsourcing Versus Crowdsourcing

To the best of our knowledge, our study is the first to examine friendsourcing and crowdsourcing as a tool to support caregivers of people with AD. Studies have looked at medical and behavioral science applications of crowdsourcing. Yu et al found that medical pictogram responses from the crowdsourcing platform Mechanical Turk were comparable with responses solicited in laboratory studies [47]. They concluded that the platform could be used as a low-cost alternative to traditional experimental studies. Other work has found similar results in using Mechanical Turk as a venue to collect survey responses [58], run behavioral experiments [59], collect natural language samples [60], and build more complex algorithms that leverage human computation [61].

Social Media for Caregivers and Emotional Support

With the changes brought by Web 2.0, social media became another means of collecting health care information [62]. Facebook remains the most widely used social media platform among the 73% of online adults who use a social networking website [63]. A few of the benefits of using social media as reported by adults seeking health care information are interactions with others with the same condition, increased availability of information, and emotional support [52,64]. Tailoring information and experience to suit personal needs is another benefit that draws users [52]. Caregiver use of the Internet and social media is greater than that of noncaregivers. In a survey of caregivers' online health behaviors, caregivers used the Internet to obtain health information more than noncaregivers, at 72% and 50%, respectively [65]. In the same survey, 52% of caregivers participated in online social activity as compared with 33% of noncaregivers. [65].

Online peer support groups provide caregivers with a common platform to address emotional needs [66,67]. In addition to being able to share personal problems and stories and to seek advice in an easy-to-access venue, caregivers also feel empowered by the group experience that affords intimacy and bonding [67]. Colvin et al reported that the anonymity afforded by Internet-based social support made users more comfortable with using online support groups as compared with their face-to-face alternatives [68]. Also, the asynchronous and immediate availability of information or answers to questions accommodate caregiving needs, such as not having to leave the care recipient and finding answers faster.

Ethical Considerations

The collaborative nature of social media leads to information collated from disparate sources, which could be inconsistent with a health care professional's knowledge and opinions. Peer-to-peer communication does not ensure the regulation and validity of information. Users often report that they crosschecked information online or waited for consensus to develop in a group before they regard a piece of information as credible [69]. The task of processing large volumes of online information and deriving insights falls on the users. Medical providers often express concerns that inaccurate health information will be shared in online communities [70]. Most online communities address this issue through online moderation.

For many online communities, moderation is limited to policing of requests for answers to clinical questions. In these situations, moderators will typically close a post and indicate to a user that he or she should see his or her doctor to address this question or a "SeeDoc" thread [29]. Downsides to this approach include missed opportunities for sharing of experiences, informational support, and emotional support. Some authors argue that peers offer an expertise distinct from the medical expertise of health care professionals [71].

In unmoderated online peer support groups, nonparticipation or reading-without-posting behavior has been identified as a drawback that reduces overall group interaction and the development of mutual aid [30]. With our study design, we showed that an online social media peer support group was feasible. Moderation in our study reduced reading-without-posting behavior.

Future Research

Work presented here included the limited analysis of the first group of our study cohort. Following completion of the project (2 more groups), we hope to gain further insights into how member interaction is influenced by friendsourced answers. We are also interested in learning how caregiver outcomes may be modified by an online support group and friendsourced support.

A similar study with a larger sample size and longer intervention is needed to determine the effectiveness of the intervention on caregiver outcomes and the overall sustainability of the intervention. Determination of effectiveness would also allow for comparisons with other existing caregiver interventions. We believe there would be value in adding caregiver mental health outcomes to future studies, as a modification of these outcomes by either crowdsourcing or friendsourcing could have wide implications. Additionally, it would be helpful to redesign the study to allow for a systematic comparison of support received from crowdsourcing, friendsourcing, and interactions between group members. Further study of the extended networks and the impact of ad hoc supportive members is also needed. In future work, we plan to complete a qualitative analysis of the open-ended questions answered in the preintervention and postintervention study interviews.

Friendsourcing and crowdsourcing offer new opportunities for caregivers of people with AD to receive informational and emotional support; however, concerns still exist around delivery of inaccurate health information. More work needs to be done to assess the quality of information received through these platforms. The growth of social media and online health community participation in the United States make the need for this work even more important, as people are likely to continue to use these online venues.

Conclusions

We found this asynchronous, online, closed group on Facebook to be generally acceptable by the peer support group studied as

a means to deliver support to AD caregivers. Implications could be wide reaching if larger studies find a significant impact on caregiver outcomes, as a similar intervention could be applied to caregivers of other diseases, such as cancer, serious mental illness, and developmental disabilities.

Both friendsourcing and crowdsourcing displayed potential as novel delivery methods of emotional and informational support to AD caregivers. Friendsourced answers demonstrated higher rates of shared experiences, which suggests that friendsourcing may be superior.

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Conflicts of Interest

None declared.

References

1. Prince M, Bryce R, Albanese E, Wimo A, Ribeiro W, Ferri CP. The global prevalence of dementia: a systematic review and metaanalysis. Alzheimers Dement 2013 Jan;9(1):63-75.e2. [doi: 10.1016/j.jalz.2012.11.007] [Medline: 23305823]
2. Goodman RA, Lochner KA, Thambisetty M, Wingo TS, Posner SF, Ling SM. Prevalence of dementia subtypes in United States Medicare fee-for-service beneficiaries, 2011-2013. Alzheimers Dement 2017 Jan;13(1):28-37. [doi: 10.1016/j.jalz.2016.04.002] [Medline: 27172148]
3. Family Caregiver Alliance. Caregiver statistics: demographics. San Francisco, CA: National Center on Caregiving; 2016. URL: https://www.caregiver.org/print/23216 [accessed 2016-10-16] [WebCite Cache ID 6lIwVUG5A]
4. Gaugler JE, Kane RL, Kane RA, Newcomer R. Unmet care needs and key outcomes in dementia. J Am Geriatr Soc 2005 Dec;53(12):2098-2105. [doi: 10.1111/j.1532-5415.2005.00495.x] [Medline: 16398893]
5. Gilhooly KJ, Gilhooly MLM, Sullivan MP, McIntyre A, Wilson L, Harding E, et al. A meta-review of stress, coping and interventions in dementia and dementia caregiving. BMC Geriatr 2016 May 18;16:106 [FREE Full text] [doi: 10.1186/s12877-016-0280-8] [Medline: 27193287]
6. Goren A, Montgomery W, Kahle-Wrobleski K, Nakamura T, Ueda K. Impact of caring for persons with Alzheimer's disease or dementia on caregivers' health outcomes: findings from a community based survey in Japan. BMC Geriatr 2016 Jun 10;16:122 [FREE Full text] [doi: 10.1186/s12877-016-0298-y] [Medline: 27287238]
7. Laks J, Goren A, Dueñas H, Novick D, Kahle-Wrobleski K. Caregiving for patients with Alzheimer's disease or dementia and its association with psychiatric and clinical comorbidities and other health outcomes in Brazil. Int J Geriatr Psychiatry 2016 Feb;31(2):176-185. [doi: 10.1002/gps.4309] [Medline: 26011093]
8. Liu S, Li C, Shi Z, Wang X, Zhou Y, Liu M, et al. Caregiver burden and prevalence of depression, anxiety and sleep disturbances in Alzheimer's disease caregivers in China. J Clin Nurs 2017 May;26(9-10):1291-1300. [doi: 10.1111/jocn.13601] [Medline: 27681477]
9. Covinsky KE, Newcomer R, Fox P, Wood J, Sands L, Dane K, et al. Patient and caregiver characteristics associated with depression in caregivers of patients with dementia. J Gen Intern Med 2003 Dec;18(12):1006-1014 [FREE Full text] [Medline: 14687259]
10. Schulz R, O'Brien AT, Bookwala J, Fleissner K. Psychiatric and physical morbidity effects of dementia caregiving: prevalence, correlates, and causes. Gerontologist 1995 Dec;35(6):771-791. [Medline: 8557205]
11. Neundorfer MM, McClendon MJ, Smyth KA, Strauss ME, McCallum TJ. Does depression prior to caregiving increase vulnerability to depressive symptoms among caregivers of persons with Alzheimer's disease? Aging Ment Health 2006 Nov;10(6):606-615. [doi: 10.1080/13607860600641036] [Medline: 17050089]
12. Russo J, Vitaliano PP, Brewer DD, Katon W, Becker J. Psychiatric disorders in spouse caregivers of care recipients with Alzheimer's disease and matched controls: a diathesis-stress model of psychopathology. J Abnorm Psychol 1995 Feb;104(1):197-204. [Medline: 7897043]
13. Schulz R, Belle SH, Czaja SJ, McGinnis KA, Stevens A, Zhang S. Long-term care placement of dementia patients and caregiver health and well-being. JAMA 2004 Aug 25;292(8):961-967. [doi: 10.1001/jama.292.8.961] [Medline: 15328328]
14. Yaffe K, Fox P, Newcomer R, Sands L, Lindquist K, Dane K, et al. Patient and caregiver characteristics and nursing home placement in patients with dementia. JAMA 2002 Apr 24;287(16):2090-2097. [Medline: 11966383]
15. Schulz R, Mendelsohn AB, Haley WE, Mahoney D, Allen RS, Zhang S, Resources for Enhancing Alzheimer's Caregiver Health Investigators. End-of-life care and the effects of bereavement on family caregivers of persons with dementia. N Engl J Med 2003 Nov 13;349(20):1936-1942. [doi: 10.1056/NEJMsa035373] [Medline: 14614169]
16. Suehs BT, Shah SN, Davis CD, Alvir J, Faison WE, Patel NC, et al. Household members of persons with Alzheimer's disease: health conditions, healthcare resource use, and healthcare costs. J Am Geriatr Soc 2014 Mar;62(3):435-441. [doi: 10.1111/jgs.12694] [Medline: 24576203]

17. von Känel R, Mausbach BT, Patterson TL, Dimsdale JE, Aschbacher K, Mills PJ, et al. Increased Framingham Coronary Heart Disease Risk Score in dementia caregivers relative to non-caregiving controls. Gerontology 2008;54(3):131-137 [FREE Full text] [doi: 10.1159/000113649] [Medline: 18204247]
18. Roepke SK, Chattillion EA, von Känel R, Allison M, Ziegler MG, Dimsdale JE, et al. Carotid plaque in Alzheimer caregivers and the role of sympathoadrenal arousal. Psychosom Med 2011;73(2):206-213 [FREE Full text] [doi: 10.1097/PSY.0b013e3182081004] [Medline: 21217096]
19. Kiecolt-Glaser JK, Dura JR, Speicher CE, Trask OJ, Glaser R. Spousal caregivers of dementia victims: longitudinal changes in immunity and health. Psychosom Med 1991;53(4):345-362. [Medline: 1656478]
20. Schulz R, Beach SR. Caregiving as a risk factor for mortality: the Caregiver Health Effects Study. JAMA 1999 Dec 15;282(23):2215-2219. [Medline: 10605972]
21. Christakis NA, Allison PD. Mortality after the hospitalization of a spouse. N Engl J Med 2006 Feb 16;354(7):719-730. [doi: 10.1056/NEJMsa050196] [Medline: 16481639]
22. Thinnes A, Padilla R. Effect of educational and supportive strategies on the ability of caregivers of people with dementia to maintain participation in that role. Am J Occup Ther 2011;65(5):541-549. [Medline: 22026322]
23. Gottlieb BH, Wolfe J. Coping with family caregiving to persons with dementia: a critical review. Aging Ment Health 2002 Nov;6(4):325-342. [doi: 10.1080/1360786021000006947] [Medline: 12425767]
24. Kneebone II, Martin PR. Coping and caregivers of people with dementia. Br J Health Psychol 2003 Feb;8(Pt 1):1-17. [doi: 10.1348/135910703762879174] [Medline: 12643813]
25. Pusey H, Richards D. A systematic review of the effectiveness of psychosocial interventions for carers of people with dementia. Aging Ment Health 2001 May;5(2):107-119. [doi: 10.1080/13607860120038302] [Medline: 11511058]
26. Li R, Cooper C, Austin A, Livingston G. Do changes in coping style explain the effectiveness of interventions for psychological morbidity in family carers of people with dementia? A systematic review and meta-analysis. Int Psychogeriatr 2013 Feb;25(2):204-214. [doi: 10.1017/S1041610212001755] [Medline: 23088896]
27. Helgeson VS, Gottlieb BH. Support groups. In: Cohen S, Underwood LG, Gottlieb BH, Fetzer Institute , editors. Social Support Measurement and Intervention: A Guide for Health and Social Scientists. Oxford, UK: Oxford University Press; 2000:221-245.
28. Vlahovic T, Wang Y, Kraut R, Levine J. Support matching and satisfaction in an online breast cancer support community. New York, NY: ACM Press; 2014 Presented at: SIGCHI Conference on Human Factors in Computing Systems; April 26-May 1, 2014; Toronto, ON, Canada p. 1625-1634. [doi: 10.1145/2556288.2557108]
29. Huh J. Clinical questions in online health communities: the case of “See your doctor” threads. CSCW 2015;2015:1488-1499 [FREE Full text] [doi: 10.1145/2675133.2675259] [Medline: 26146665]
30. Wilkerson D. Lurking behavior in online psychosocial discussion forums: theoretical perspectives and implications for practice. J Technol Hum Serv 2016 Jul 02;34(3):256-266. [doi: 10.1080/15228835.2016.1193456]
31. van Mierlo T. The 1% rule in four digital health social networks: an observational study. J Med Internet Res 2014;16(2):e33 [FREE Full text] [doi: 10.2196/jmir.2966] [Medline: 24496109]
32. Nielsen J. Participation inequality: the 90-9-1 rule for social features. 2006. URL: https://www.nngroup.com/articles/participation-inequality/ [accessed 2016-10-16] [WebCite Cache ID 6lJ2Lz1Fk]
33. Quinn A, Bederson B. Human computation: a survey and taxonomy of a growing field. New York, NY: ACM; 2011 Presented at: SIGCHI Conference on Human Factors in Computing Systems; May 7-12, 2011; Vancouver, BC, Canada p. 1403-1412. [doi: 10.1145/1978942.1979148]
34. Morris RR, Picard R. Crowdsourcing collective emotional intelligence. 2012 Presented at: Collective Intelligence Conference; April 18-20, 2012; Cambridge, MA, USA.
35. Bernstein MS, Tan D, Smith G, Czerwinski M, Horvitz E. Personalization via friendsourcing. ACM Trans Comput Hum Interact 2010 May 01;17(2):1-28. [doi: 10.1145/1746259.1746260]
36. Morris M, Teevan J, Panovich K. What do people ask their social networks, and why? A survey study of status message q&a behavior. New York, NY: ACM Press; 2010 Presented at: SIGCHI Conference on Human Factors in Computing Systems; April 10-15, 2010; Atlanta, GA, USA p. 1739-1748. [doi: 10.1145/1753326.1753587]
37. Zhang Y, He D, Sang Y. Facebook as a platform for health information and communication: a case study of a diabetes group. J Med Syst 2013 Jun;37(3):9942. [doi: 10.1007/s10916-013-9942-7] [Medline: 23588823]
38. Burke M, Marlow C, Lento T. Social network activity and social well-being. New York, NY: ACM Press; 2010 Presented at: SIGCHI Conference on Human Factors in Computing Systems; April 10-15, 2010; Atlanta, GA, USA p. 1909-1912. [doi: 10.1145/1753326.1753613]
39. Brady E, Morris M, Bigham J. Gauging receptiveness to social microvolunteering. New York, NY: ACM; 2015 Presented at: 33rd Annual ACM Conference on Human Factors in Computing Systems; April 18-23, 2015; Seoul, Republic of Korea p. 1055-1064. [doi: 10.1145/2702123.2702329]
40. Bédard M, Molloy DW, Squire L, Dubois S, Lever JA, O'Donnell M. The Zarit Burden Interview: a new short version and screening version. Gerontologist 2001 Oct;41(5):652-657. [Medline: 11574710]
41. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983 Dec;24(4):385-396. [Medline: 6668417]

42. Steffen AM, McKibbin C, Zeiss AM, Gallagher-Thompson D, Bandura A. The revised scale for caregiving self-efficacy: reliability and validity studies. J Gerontol B Psychol Sci Soc Sci 2002 Jan;57(1):P74-P86. [Medline: 11773226]
43. Sherbourne CD, Stewart AL. The MOS social support survey. Soc Sci Med 1991;32(6):705-714. [Medline: 2035047]
44. Xie SX, Ewbank DC, Chittams J, Karlawish JHT, Arnold SE, Clark CM. Rate of decline in Alzheimer disease measured by a Dementia Severity Rating Scale. Alzheimer Dis Assoc Disord 2009;23(3):268-274 [FREE Full text] [doi: 10.1097/WAD.0b013e318194a324] [Medline: 19812470]
45. Cummings JL, Mega M, Gray K, Rosenberg-Thompson S, Carusi DA, Gornbein J. The Neuropsychiatric Inventory: comprehensive assessment of psychopathology in dementia. Neurology 1994 Dec;44(12):2308-2314. [Medline: 7991117]
46. Ellison N, Steinfield C, Lampe C. The benefits of Facebook “friends:” social capital and college students' use of online social network sites. J Comput Mediat Commun 2007 Jul;12(4):1143-1168. [doi: 10.1111/j.1083-6101.2007.00367.x]
47. Yu B, Willis M, Sun P, Wang J. Crowdsourcing participatory evaluation of medical pictograms using Amazon Mechanical Turk. J Med Internet Res 2013;15(6):e108 [FREE Full text] [doi: 10.2196/jmir.2513] [Medline: 23732572]
48. Mason W, Suri S. Conducting behavioral research on Amazon's Mechanical Turk. Behav Res Methods 2012 Mar;44(1):1-23. [doi: 10.3758/s13428-011-0124-6] [Medline: 21717266]
49. Kittur A, Nickerson J, Bernstein M, Gerber E, Shaw A, Zimmerman J. The future of crowd work. New York, NY: ACM Press; 2013 Presented at: 2013 Conference on Computer Supported Cooperative Work; February 23-27, 2013; San Antonio, TX, USA p. 1301. [doi: 10.1145/2441776.2441923]
50. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006 Jan;3(2):77-101. [doi: 10.1191/1478088706qp063oa]
51. Wang Y, Kraut R, Levine J. To stay or leave? The relationship of emotional and informational support to commitment in online health support groups. New York, NY: ACM Press; 2012 Presented at: ACM 2012 conference on Computer Supported Cooperative Work; February 11-15, 2012; Seattle, WA, USA p. 833-842. [doi: 10.1145/2145204.2145329]
52. Moorhead SA, Hazlett DE, Harrison L, Carroll JK, Irwin A, Hoving C. A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication. J Med Internet Res 2013;15(4):e85 [FREE Full text] [doi: 10.2196/jmir.1933] [Medline: 23615206]
53. Ipeirotis PG. Demographics of Mechanical Turk. 2010. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1585030 [accessed 2016-10-29] [WebCite Cache ID 6lc2RbbWG]
54. Ugander J, Karrer B, Backstrom L, Marlow C. The anatomy of the Facebook social graph. Ithaca, NY: arXiv, Cornell University Library; 2011 Nov 18. URL: https://arxiv.org/pdf/1111.4503.pdf [accessed 2017-04-04] [WebCite Cache ID 6pTkbWk73]
55. Duggan M, Ellison NB, Lampe C, Lenhart A, Madden N. Social media update 2014. Washington, DC: Pew Research Center; 2015 Jan 09. URL: http://www.pewinternet.org/2015/01/09/social-media-update-2014/ [accessed 2016-10-29] [WebCite Cache ID 6lc2G09li]
56. Ross J, Irani L, Silberman M, Zaldivar A, Tomlinson B. Who are the crowdworkers? Shifting demographics in mechanical turk. New York, NY: ACM; 2010 Presented at: CHI10 Extended Abstracts on Human Factors in Computing Systems; April 10-15, 2010; Atlanta, GA. USA p. 2863-2872. [doi: 10.1145/1753846.1753873]
57. Rains S, Young V. A meta-analysis of research on formal computer-mediated support groups: examining group characteristics and health outcomes. Hum Commun Res 2009 Jul;35(3):309-336. [doi: 10.1111/j.1468-2958.2009.01353.x]
58. Kittur A, Chi E, Suh B. Crowdsourcing user studies with Mechanical Turk. New York, NY: ACM; 2008 Presented at: SIGCHI Conference on Human Factors in Computing Systems; April 5-10, 2008; Florence, Italy p. 453-456.
59. Rand DG. The promise of Mechanical Turk: how online labor markets can help theorists run behavioral experiments. J Theor Biol 2012 Apr;299:172-179. [doi: 10.1016/j.jtbi.2011.03.004]
60. Saunders DR, Bex PJ, Woods RL. Crowdsourcing a normative natural language dataset: a comparison of Amazon Mechanical Turk and in-lab data collection. J Med Internet Res 2013 May 20;15(5):e100 [FREE Full text] [doi: 10.2196/jmir.2620] [Medline: 23689038]
61. Little G, Chilton L, Goldman M, Miller R. Turkit: human computation algorithms on mechanical turk. New York, NY: ACM; 2010 Presented at: 23rd Annual ACM Symposium on User Interface Software and Technology; New York, NY, USA; October 3-6, 2010 p. 57-66.
62. Eysenbach G. Medicine 2.0: social networking, collaboration, participation, apomediation, and openness. J Med Internet Res 2008;10(3):e22 [FREE Full text] [doi: 10.2196/jmir.1030] [Medline: 18725354]
63. Duggan M, Smith A. Social media update 2013. Washington, DC: Pew Research Center; 2013. URL: http://www.pewinternet.org/2013/12/30/social-media-update-2013/ [accessed 2017-04-06] [WebCite Cache ID 6pX3tWBEU]
64. Cline RJ, Haynes KM. Consumer health information seeking on the Internet: the state of the art. Health Educ Res 2001 Dec;16(6):671-692 [FREE Full text] [Medline: 11780707]
65. Fox S, Duggan M, Purcell K. Family caregivers are wired for health. Washington, DC: Pew Research Center; 2013 Jun 20. URL: http://www.pewinternet.org/2013/06/20/family-caregivers-are-wired-for-health/ [accessed 2016-10-16] [WebCite Cache ID 6lJ7xNq2a]
66. Barak A, Boniel-Nissim M, Suler J. Fostering empowerment in online support groups. Comput Hum Behav 2008 Sep;24(5):1867-1883. [doi: 10.1016/j.chb.2008.02.004]

67. Heller T, Roccoforte JA, Hsieh K, Cook JA, Pickett SA. Benefits of support groups for families of adults with severe mental illness. Am J Orthopsychiatry 1997 Apr;67(2):187-198. [Medline: 9142352]
68. Colvin J, Chenoweth L, Bold M, Harding C. Caregivers of older adults: advantages and disadvantages of internet-based social support. Fam Relat 2004 Jan;53(1):49-57. [doi: 10.1111/j.1741-3729.2004.00008.x]
69. Lederman R, Fan H, Smith S, Chang S. Who can you trust? Credibility assessment in online health forums. Health Policy Technol 2014 Mar;3(1):13-25. [doi: 10.1016/j.hlpt.2013.11.003]
70. Johnson GJ, Ambrose PJ. Neo-tribes: the power and potential of online communities in health care. Commun ACM 2006 Jan 01;49(1):107-113. [doi: 10.1145/1107458.1107463]
71. Hartzler A, Pratt W. Managing the personal side of health: how patient expertise differs from the expertise of clinicians. J Med Internet Res 2011;13(3):e62 [FREE Full text] [doi: 10.2196/jmir.1728] [Medline: 21846635]

Abbreviations

AD: Alzheimer disease
FBI: Facebook Intensity Scale
MOS: Medical Outcomes Study
PSS-14: Perceived Stress Scale-14
ZBI-12: Zarit Burden Interview Short Form

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Original Paper

Increasing Fruit and Vegetable Consumption Through a Healthy Eating Blog: A Feasibility Study

Marie-Eve Caplette[1,2], RD, MSc; Véronique Provencher[1], RD, PhD; Véronique Bissonnette-Maheux[1], RD, MSc; Marilyn Dugrenier[1], RD; Annie Lapointe[1], RD, PhD; Marie-Pierre Gagnon[3], PhD; Sharon Straus[4], MSc, MD; Sophie Desroches[1,2], RD, PhD

[1]Institute of Nutrition and Functional Foods, Laval University, Quebec, QC, Canada

[2]Population Health and Optimal Health Practices Research Unit, CHU de Québec Research Center, Quebec, QC, Canada

[3]Faculty of Nursing, Laval University, Quebec, QC, Canada

[4]Department of Medicine, University of Toronto, Toronto, ON, Canada

Corresponding Author:
Sophie Desroches, RD, PhD
Institute of Nutrition and Functional Foods
Laval University
Pavillon des services, office 2729-P
2440 Hochelaga Boulevard
Quebec, QC, G1V 0A6
Canada
Phone: 1 418 656 2131 ext 5564
Fax: 1 418 656 2131
Email: sophie.desroches@fsaa.ulaval.ca

Abstract

Background: Despite efforts made by public health organizations to improve consumption of fruits and vegetables, populations in developed countries usually eat less than the minimum recommended. Social media, such as blogs, represent a unique opportunity for improving knowledge translation in health care because they facilitate interactive communication between the public and health professionals. However, no studies have yet evaluated the effect of blogs to promote dietary behavior changes.

Objective: Our study aims to conduct a preliminary assessment before undertaking a full randomized controlled trial (RCT) of the feasibility of using an evidence-based healthy eating blog promoting the consumption of fruits and vegetables among adult women.

Methods: A total of 80 women aged 18 years and older (mean 42, SD 13 years) eating less than five servings per day of fruit and vegetables (mean 2.75, SD 1.84 servings) were recruited. Participants were randomized to the healthy eating blog group (n=40), which included a weekly blog post over a 6-month period, or to a control group (n=40) that had no exposure to the healthy eating blog. Blog posts were written by a registered dietitian and focused on the improvement of fruit and vegetable consumption. We targeted four main determinants of the behavior that were identified as the best predictors for fruit and vegetable intake by two systematic reviews: (1) knowledge, (2) attitude, (3) self-efficacy, and (4) motivation. The intervention was considered feasible if (1) more than 70% of questionnaires were completed, (2) attendance rate was more than 90% for in-person appointments with the research coordinator, (3) participants accessed at least 75% of the blog posts, and (4) the attrition rate was less than 25%. Blog access was assessed by collecting the blog browsing history data for each participant.

Results: During the intervention, 26 posts were published on the blog. Pre- (baseline) and postintervention (6 months) questionnaires were completed by mean 97% (SD 3%) of participants. All participants attended their in-person appointments. Women accessed mean 87% (SD 7%) of the posts published during the intervention. Only 3% (2/80) of participants dropped out of the study. Between the healthy eating blog and control groups, a difference of 1.0 servings of fruits and vegetables (P<.001) indicated moderate effects of the intervention (Cohen d=0.54).

Conclusions: These results suggest that an intervention using a healthy eating blog meets preestablished feasibility criteria. A larger-scale RCT using the same methodology will be conducted to assess the impact of a healthy eating blog on the dietary habits of women.

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KEYWORDS

blogs; nutrition; healthy eating; knowledge translation; feasibility

Introduction

Healthy Eating

The incidence of chronic diseases has dramatically increased worldwide [1]. The adoption of a healthy diet is recognized as the cornerstone in the prevention and management of chronic diseases [2-4], which are the leading cause of mortality and disability worldwide [1]. One of the best indicators of diet quality is high fruit and vegetable consumption [5], which can help achieve or maintain a healthy body weight [6] and reduce the risk of some cancers [7] and cardiovascular diseases [8]. Accordingly, the World Health Organization recommends a daily consumption of at least 400 grams of fruits and vegetables for the prevention of chronic diseases [9], which corresponds to five servings of fruits and vegetables in Canada's Food Guide [10]. In Canada, despite the establishment of health promotion initiatives aiming to increase fruit and vegetable consumption, only 40% of Canadians aged 12 years and older consumed at least five servings daily in 2014 [11]. The situation is similar in the United States and in other developed countries [12-14].

Although it is clear that the adoption of preventive behaviors such as a healthy diet is associated with health benefits, nonadherence rates to medication and lifestyle changes are estimated to be 50% in developed countries [15]. Recent systematic reviews have shed light on interventions that best promote dietary behavior change and, thus, adherence to a healthy diet [16]. More specific to fruit and vegetable consumption, systematic reviews aimed at identifying theoretically derived psychosocial determinants of fruit and vegetable intake reported that habit, motivation/goals, beliefs about capabilities/self-efficacy, knowledge, and social support were consistently identified as important determinants of fruit and vegetable consumption [17,18]. Although the previously mentioned systematic reviews contribute to our knowledge about the effective components that should be included in dietary behavior change interventions, much remains unknown about the knowledge translation strategies that should be used to optimally deliver these interventions so that individuals successfully improve their dietary habits.

Social Media Interventions

Chronic disease prevention and management require sustained lifestyle behavior changes and a long-term commitment, which can require help from a health professional. However, dietary counseling may not be accessible for some patients, such as those living in rural areas, having inflexible working hours and schedule, or having reduced mobility. To overcome these barriers and to inform preventive health care quality improvement, social media interventions in nutrition, such as blogs, could be an effective strategy to reach a large proportion of the Internet population with diverse sociodemographic characteristics, independently of education, race/ethnicity, or health care access [19,20]. Blogs are websites where entries, called *posts*, are written by individuals or a group of individuals including health professionals [21]. Blogs display unique features such as interactivity, social support, and convenience, which could make them valuable additions or alternatives in some cases to traditional face-to-face clinical encounters [22,23]. Another interesting feature of blogs is that bloggers have been found to act as knowledge brokers by playing a crucial role in directing their readers through opinions and hyperlinks [24].

Purpose of the Feasibility Study

Despite the fact that health blogs are proliferating at high speed, there is no empirically supported knowledge on the impact of health blogs on consumers' health behaviors and outcomes to promote healthy dietary behavior changes (eg, increase fruit and vegetable intake). To our knowledge, no study has yet evaluated the effects of an evidence-based healthy eating blog on women's dietary and eating behaviors. Moreover, attrition rates, which refers to the proportion of users who drop out before completion of the study [25], are high in most Web-based health interventions [26-29]. Therefore, as a first step before conducting a randomized controlled trial (RCT), the purpose of this pilot study was to assess the feasibility of a dietary intervention using a healthy eating blog written by a registered dietitian through collecting blog browsing history data for each participant to determine compliance rates, participation rates, and attrition rates.

As a secondary objective, we intended to collect clinical data such as fruit and vegetable consumption and anthropometric measurements. Although this feasibility trial was not powered to detect differences in these outcomes, their assessments will be useful to evaluate the data collection tools. It will also provide an indication of the variance in measurement (effect size) to be used for the power calculation for the definitive RCT.

Methods

Study Design

This study was a randomized feasibility trial comparing two groups: control and healthy eating blog (access to the healthy eating blog). The sample size for feasibility trials is typically determined pragmatically, with recommendations of a minimum of 30 participants per group [30,31], which is what we aimed for in our study (n=40 per group to account for dropouts). This study was created according to Thabane's checklist for pilot studies [32].

Participants and Recruitment

An advertisement was sent to a list of people who had indicated interest in participating in the Institute of Nutrition and Functional Foods clinical studies. Also, some members of the research team posted the ad on their personal Facebook page. The eligibility of participants was assessed over the phone based on the following inclusion criteria: (1) a woman aged 18 and older living in the Quebec City metropolitan area, (2) has

Internet access as well as an active email address, and (3) consumes less than five servings of fruits and vegetables per day (assessed with a 24-hour recall performed by a registered dietitian). We chose to focus the intervention on women because they are primarily responsible for food purchase and preparation in households. Therefore, nutrition promotion strategies that target women have the potential for reach that goes beyond the individual and can thereby improve their family's health [33,34]. Moreover, a vast majority of dietitian bloggers are women, with a readership predominantly made of women, so our study was shaped around what is available in terms of nutrition blogs [35-37].

Eligible participants were randomized by the research coordinator, who generated a random order list using the Institute of Nutrition and Functional Foods (INAF)'s Web platform. Participants were then scheduled for an in-person individual first visit at the research center to complete a baseline clinical outcomes assessment. All participants gave written informed consent and received Can $100 financial compensation at their final visit at INAF. This project was approved by the ethics committee of Laval University (2014-084 on May 21, 2014).

Intervention

Preliminary Phase

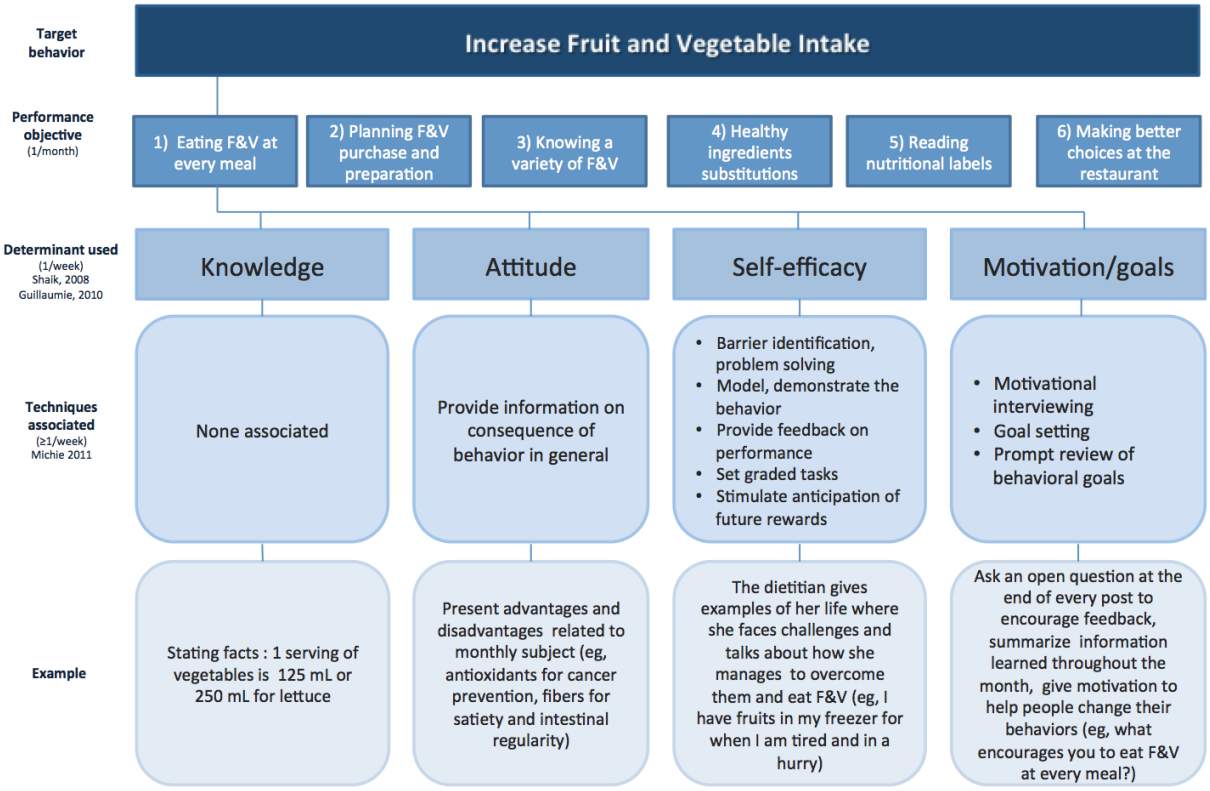
As a preliminary step, in 2013 we performed a qualitative study exploring women's views and expectations regarding healthy eating blogs as a means to improve their dietary behaviors [38]. Focus groups and individual interviews allowed us to identify the main facilitators and barriers to using a healthy eating blog and preferred key features. The interviews revealed that women preferred blogs that clearly identified the dietitian-blogger: name, picture, academic education, and professional experience. Women also liked beautiful food pictures, recipes that allowed them to apply dietary advice addressed in the posts, and videos showing new cooking techniques. They also mentioned they appreciated when the dietitian-blogger included scientific references at the end of the post. These data were used to develop the healthy eating blog.

Intervention Development

The development of the intervention was inspired by the steps of the Intervention Mapping protocol [39] and the results of the preliminary phase described previously [38]. The target behavior of the healthy eating blog was to increase fruit and vegetable consumption. Therefore, blog posts aimed at discussing various positive aspects of healthy eating with a focus on fruit and vegetable intake.

Based on clinical experience of the registered dietitians on the research team and on national and international public health campaigns [40-42], six performance objectives were chosen to improve the target behavior (Figure 1). The performance objectives chosen were, in chronological order of appearance on the blog, (1) eating fruit and vegetables at every meal, (2) planning fruit and vegetables purchase and preparation, (3) knowing a variety of fruit and vegetables, (4) healthy ingredient substitutions in recipes, (5) reading nutritional labels, and (6) making better choices at the restaurant. Based on two recent systematic reviews [17,18] that aimed to review psychosocial determinants of adult fruit and vegetable consumption from different theories and their constructs, we identified the most significant psychosocial determinants of fruit and vegetable consumption applicable to blogs: (1) knowledge, (2) attitude, (3) self-efficacy, and (4) motivation/goals. For each performance objective, we focused on one psychosocial determinant per week. Finally, to promote fruit and vegetable intake through these psychosocial determinants, we used Abraham and Michie's taxonomy of effective behavior change techniques [43,44]. This taxonomy has been used in multiple studies [45,46] and helped clarify the evidence base about behavior change, allowing specification of interventions in published reports and improving replication, implementation, and evidence synthesis. The platform used to build the blog was WordPress.

Figure 1. Conceptual framework of the intervention. F&V: fruits and vegetables.

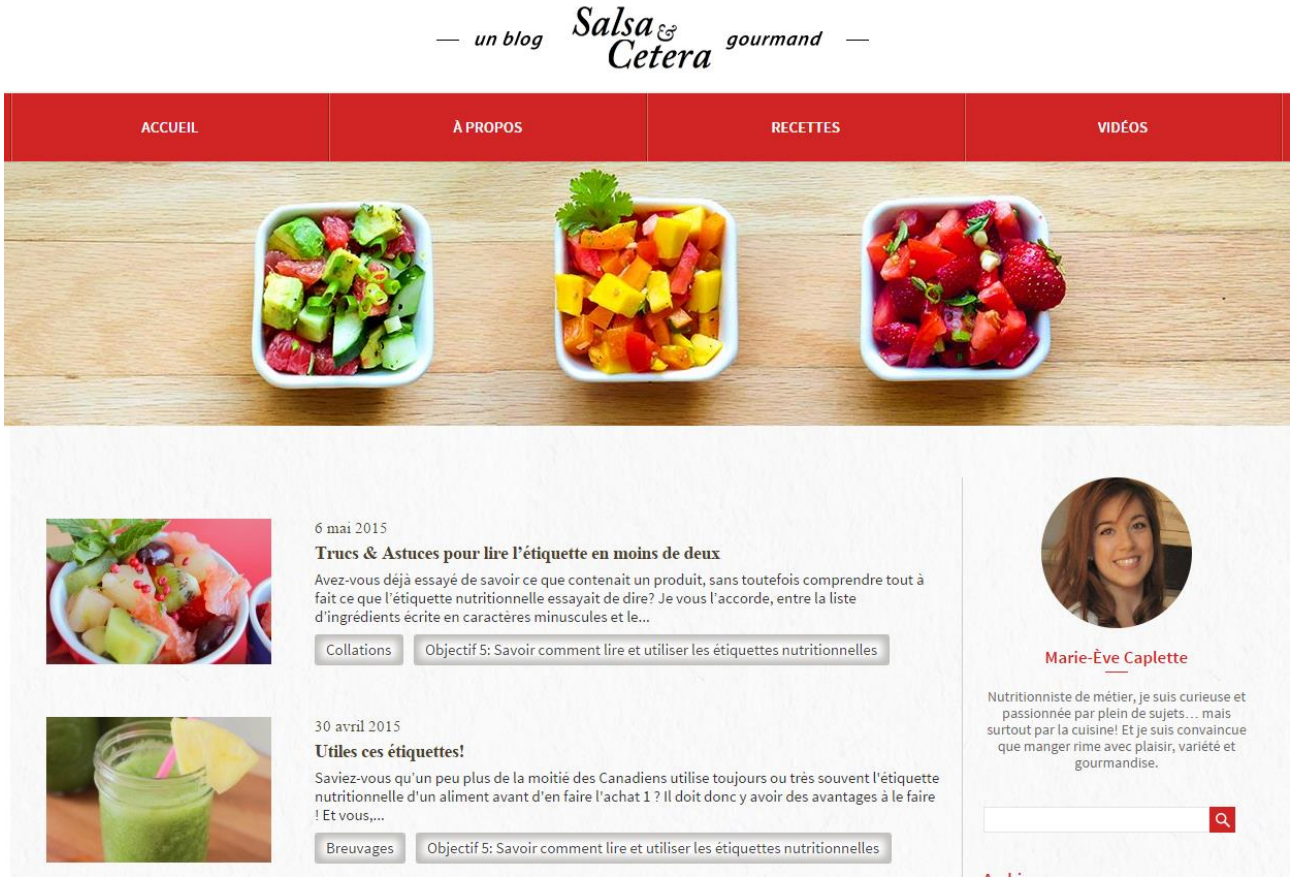


Intervention Procedure

The 6-month intervention started on January 13, 2015. Participants received an email to inform them of their allocation (control group or healthy eating blog group). Women in the healthy eating blog group received an identification code and a password to access the healthy eating blog as well as instructions on how to navigate the experimental blog website entitled “Salsa Etcetera” (Figure 2), and how to add comments. They were invited to consult the first two published posts on the healthy eating blog. The research coordinator (coauthor VBM) was available throughout the study to support participants with any issues related to the use of the blog website, while the dietitian-blogger (first author MEC) was primarily responsible for the content of the blog posts, each of which was discussed with coauthors SD and VP. To thank participants in the control group for participating to our study, we gave them a user code and a password after the 6-month intervention that gave them access to the healthy eating blog posts. However, they could not comment or interact with the dietitian-blogger.

Blog posts and comments were read and reviewed by the team of researchers and dietitians before they were published online. Each post included a step-by-step recipe developed by the research team that featured fruits and vegetables. Recipes were described using text and pictures and/or video. Twenty-six posts were created over the 6-month intervention, including the two that were already on the blog when the participants first logged on. Because the majority of women who participated in our preliminary phase mentioned they would like a weekly post to be published (as opposed to twice a week or once every two weeks), participants received a new blog post once a week for 24 weeks. An email was sent every week to inform them that a new post was on the blog. We also sent an email reminder to participants who did not log on the blog for two consecutive weeks.

Figure 2. Home page of the intervention healthy eating blog "Salsa Etcetera.".



Data Collection

All participants were seen at the INAF twice during the study: once at the beginning and once at the end of the 6-month intervention to complete Web-based questionnaires and for anthropometric measurements using standardized procedures (height, weight, and waist circumference) [47]. Body mass index (BMI) was calculated based on measured height and weight. We asked participants to complete a total of six Web questionnaires, including a sociodemographic questionnaire (42 questions), a validated food frequency questionnaire (FFQ; 136 questions) [48], the Three-Factor Eating Questionnaire (a 51-item validated questionnaire) [49], the Restraint Scale (a validated 11-item questionnaire) [50], the Intuitive Eating Scale (a validated 21-item questionnaire) [51], and a social support questionnaire (2 questions). A final questionnaire (4 questions) was added following the intervention to document whether women had been on a specific diet that could affect their food intake over the study period. Participants in the healthy eating blog group also received a monthly Web questionnaire assessing perceived utility of the blog posts. For example, they were asked their opinion about the posts published, if information presented was useful, and if they would use this information in the future.

Feasibility was assessed by evaluating compliance rates, participation rates, and attrition rates. Compliance rates were measured for the 80 participants by the (1) completion of questionnaires assessing clinical outcome data measures for our definitive RCT (change in fruit and vegetable intake, changes in eating behaviors, social support, body weight) and (2) attendance at in-person appointments with the research coordinator. Based on a previous study at INAF that involved the completion of a similar number of questionnaires [52], completion of the questionnaire was considered feasible if it exceeded 70%. The target of attendance for in-person appointments at INAF was 90%. Participation rates were assessed through frequency of use, which was measured primarily by recording the number of posts women accessed out of the 26 published, but also by the number of comments made to the dietitian-blogger's posts and replies to their peers' comments initiated by participants. For this specific feasibility outcome, we expected participants to access 75% of the blog posts over the 6 months. The control group did not have access to the blog, so these data were collected for the 40 healthy eating blog participants using Google Analytics and the Web platform (WordPress). Based on a systematic review of Web interventions for changing dietary behaviors [53], we considered the attrition rate acceptable if it was less than 25%.

This feasibility study was not designed to achieve sufficient statistical power to address behavioral outcomes. However, these outcome measures were useful to provide better guidance with regard to development of the definitive RCT. Among the behavioral outcomes of interest, fruit and vegetable intake was assessed with a validated Web-based FFQ [48] at baseline and 6 months. The Web FFQ is an online self-administered quantitative FFQ that allows measuring usual dietary intake over a 1-month period.

Statistical Analysis

The program SAS was used to analyze data obtained from the questionnaires and to calculate descriptive statistics of the healthy eating blog group and the control group. We used *t* tests to compare the two groups and the generalized linear model procedure to evaluate the effect of time and group on FFQ variables. Means and SD were calculated for the healthy eating blog group. Effect size measures were calculated comparing the mean for fruit and vegetable consumption postintervention of the two groups.

Results

Study Recruitment and Baseline Characteristics

Recruitment took place from October 28, 2014 to December 15, 2014 (7 weeks). During this time, eligibility was assessed for 128 women (Figure 3). Among them, 37 were excluded from the first screening for not meeting inclusion criteria (eating ≥5 portions of fruits and vegetables a day: n=34; not having access to Internet during the 6-month intervention: n=3). Eleven eligible participants did not show up at the first appointment and did not express further interest in participating in the study. A total of 80 women (63% of total responding women, n=75 recruited from the mailing list and n=5 recruited on Facebook) enrolled in the study and submitted consent forms at their first visit. Two participants left the study during the first month for personal reasons (one had a concussion and could not use a computer and the second had a death in her family and did not want to participate). Demographic information for participants is described in Table 1.

Table 1. Sociodemographic characteristics, eating habits, and Internet use characteristics of participants (N=80).

Sociodemographic, eating habits, and Internet use characteristics	Healthy eating blog (n=40)	Control (n=40)	*P*
Age (years), mean (SD)	42.0 (13.7)	42.2 (13.4)	.95
Race, n (%)			>.99
White	36 (90)	37 (93)	
Other	4 (10)	3 (8)	
Education completed, n (%)			.56
High school	6 (15)	4 (10)	
College	15 (38)	13 (33)	
University	18 (45)	23 (58)	
Did not answer	1 (2.5)	0 (0)	
Family income (Can $), n (%)			.42
0-19,999	4 (10)	2 (5)	
20,000-49,999	15 (38)	11 (28)	
50,000-99,999	12 (30)	12 (30)	
100,000-149,999	4 (10)	7 (18)	
150,000-199,999	1 (3)	1 (3)	
≥200,000	1 (3)	0 (0)	
Did not answer	3 (8)	7 (18)	
BMI (m/kg^2), mean (SD)	27.7 (5.2)	27.1 (6.4)	.21
Fruit and vegetable daily intake (servings), mean (SD)	2.45 (1.94)	3.05 (1.70)	.43
Time spent on Internet for leisure (hours/week), n (%)			.39
<1	0 (0)	1 (3)	
1-2	5 (13)	7 (18)	
3-4	12 (30)	12(30)	
5-10	17 (43)	10 (25)	
≥10	6 (15)	10 (25)	
Most-used tools for Internet navigation, n (%)			
Computer	26 (65)	30 (75)	
Smartphone	4 (10)	4 (10)	
Tablet	9 (23)	6 (15)	
Did not answer	1 (3)	0 (0)	
Places where Internet is most often used, n (%)			.85
Home	34 (85)	36 (90)	
Work	4 (10)	3 (8)	
Car or bus	1 (3)	1 (3)	
Other	1 (3)	0 (0)	
Read a blog before, n (%)	36 (90)	34 (85)	.50
Read a nutrition blog before,[a] n (%)	22 (55)	20 (50)	.65
Read comments on a blog,[a] n (%)	29 (73)	27 (68)	.63
Commented on a blog,[a] n (%)	11 (28)	8 (20)	.43

[a] Only among participants who had already read a blog before.

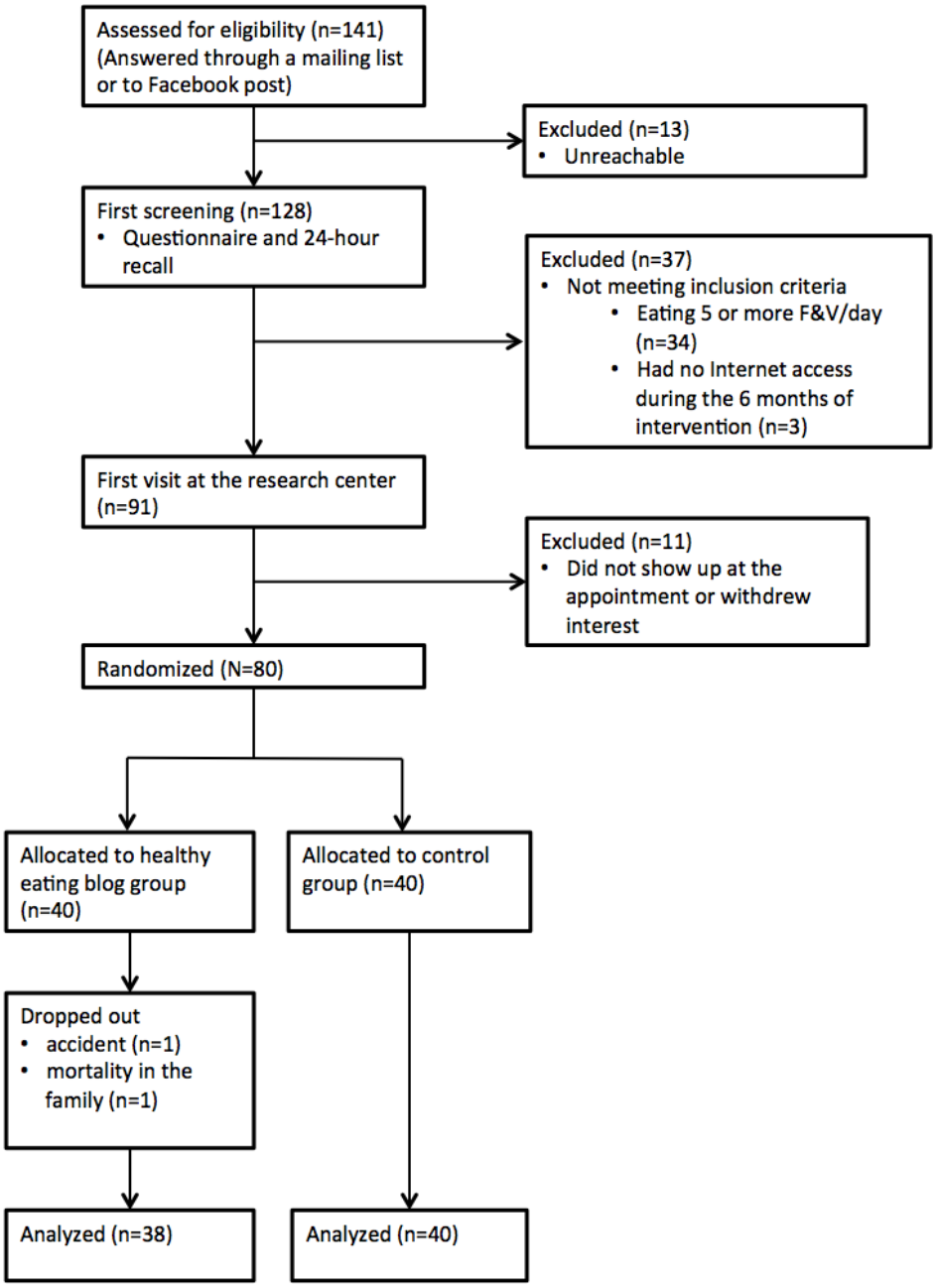
Participants were mostly white women aged between 22 and 71 years of age (mean 42, SD 14 years) and ate less than five portions of fruits and vegetables per day (mean 2.75, SD 1.83 servings). The majority of these women received college- or university-level education and more than half of respondents (38/70) had a family income greater than Can $50,000. Mean BMI was 27.5 (SD 4.6), and 31% (25/80) were obese according to Canadian Health Risk Classification (BMI ≥30) [54]. In all, 53% (42/80) had already consulted a blog before. As shown in Table 1, there were no significant differences between the two groups.

Feasibility Outcomes

Compliance Rates

Preintervention and postintervention questionnaires were completed by all participants in both the healthy eating blog and control groups. The monthly questionnaire was completed by 97% (37/38) of participants on average. The lowest completion percentage (92%, 35/38) was observed on month 4. All participants in both groups attended their in-person appointments (100%, 38/38). Therefore, compliance rates all reached our feasibility criteria.

Figure 3. Flowchart of participants. F&V: fruits and vegetables.



Participation Rates

As shown in Figure 4, each weekly post was accessed by at least 73% of women (27/37). We also filmed and edited two videos showing cooking techniques that we posted on YouTube and linked to the blog. Six of 40 participants (16%) viewed the first video, and 4 of 40 participants (11%) viewed the second (Table 2). Participants posted a total of 514 comments on the blog during the intervention. On average, each participant commented 2 (SD 0.4) times per month. Data logs were impossible to collect for one participant who had a firewall installed on her computer. Feasibility criterion was set at 75% of participants viewing each post, as shown by the bold line in Figure 4.

Table 2. Participation rates on the healthy eating blog during the 6-month intervention (n=38).[a]

Participation	Month						Total
	1	2	3	4	5	6	
Date range	Jan 13-Feb 11	Feb 12-Mar 11	Mar 12-Apr 8	Apr 9-May 6	May 7-Jun 3	Jun 4-Jul 1	
Articles posted each month, n	6	4	4	4	4	4	26
Comments							
Total comments,[b] n	141	74	80	73	71	75	514
Comments/post, mean (SD)	23.5 (9.9)	17.5 (2.0)	16.5 (2.0)	17.0 (5.5)	15.0 (1.5)	16.8 (2.8)	17.7 (4.7)
Comments/participant,[b] mean (SD)	3.7 (0.3)	1.9 (0.2)	2.1 (0.1)	1.9 (0)	1.9 (0.1)	2.0 (0.0)	13.5 (0.7)
Posts, recipes, and videos, n							
Total printed recipes[b,c]	35	19	6	10	30	27	127
Total video views[b,c,d]	0	0	0	0	6	4	10

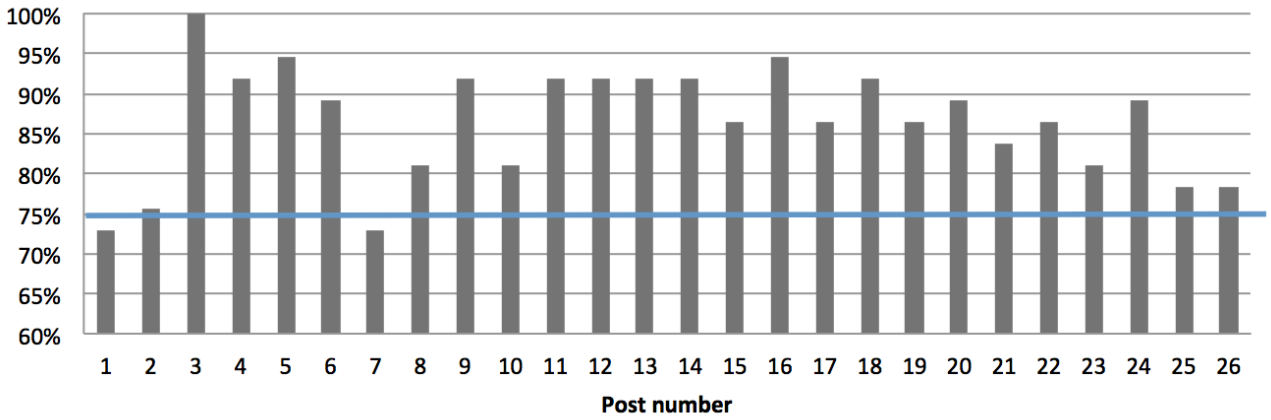
[a] n=38 because two participants dropped out.

[b] For the month's new posts and precedent posts.

[c] n=37 because data logs were impossible to collect for one participant who had a firewall installed on her computer.

[d] First video was posted on May 6 and the second video was posted on June 4. All four views during month 6 were for video 2.

Figure 4. Percentage of participants (n=37) who viewed each post. Note data logs were impossible to collect for one participant who had a firewall installed on her computer. The bold blue line represents the feasibility criterion of 75% of participants viewing each post.



Attrition Rate

The attrition rate was 3% (2/80), which is less than our preestablished 25% criteria. The two participants who dropped out were in the healthy eating blog group and the reasons were external to the study as mentioned previously.

Clinical Outcomes

We observed no significant differences in fruit and vegetable consumption between the healthy eating blog group (mean 2.44, SD 1.91 portions/day) and the control group (mean 3.05, SD 1.70 portions/day) at baseline (Figure 5). However, the healthy eating blog group significantly increased their fruit and vegetable consumption at the 6-month visit (mean 4.23, SD 1.85 portions/day, $P<.001$; mean difference 1.79, SD 2.47 portions/day), and this was significantly different from the control group (mean 3.22, SD 1.86 portions/day, $P<.001$). No significant changes in other food groups were found. The difference of 1.0 servings of fruits and vegetables ($P<.001$) found between groups indicated moderate effects of the intervention (Cohen $d=0.54$). There were no significant

differences between anthropometric measurements before and after the intervention (Cohen *d*=0.14).

Figure 5. Mean fruit and vegetable consumption for the two groups before and after the 6-month intervention (n=78).

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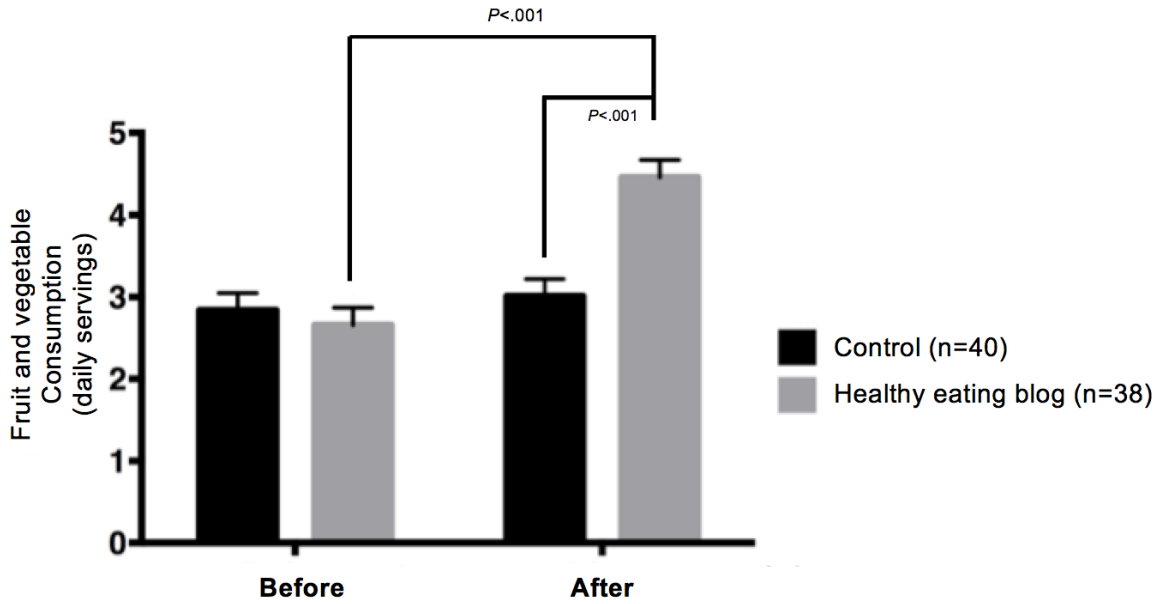

Discussion

Our study is the first to evaluate the feasibility of an intervention using an evidence-based healthy eating blog to improve women's dietary and eating behaviors. According to our preestablished criteria, the intervention is deemed feasible.

Compliance Rates

Measured completion of pre- and postintervention questionnaires (100%) and in-person appointment attendance (100%) met our preestablished compliance rate criteria. Unsurprisingly, all questionnaires were completed because participants filled them in during their in-person appointment, which everyone attended. Compliance rates were high for both the healthy eating blog and control groups. The incentive of Can $100 given at the end of the study may have contributed to compliance. Completion of the monthly questionnaires by the healthy eating blog group (mean 96.5%, SD 3.2%) also met our compliance rate criteria of 70%. The reminder sent to participants when they did not complete the monthly questionnaire may have contributed to achieving this high completion rate.

Participation Rates

It is known that increased participant use of and engagement with an intervention platform are associated with greater behavior change [55]. Our criterion to assess participation was for participants to view at least 75% of published blog posts. This criterion was met; participants viewed a mean 86.6% of posts. Only two blog posts were seen by less than 75% of participants (73% for posts 1 and 7).

In concordance with studies included in Williams et al's systematic review of RCTs examining the use of social media to promote healthy diet and exercise in the general population [26], participation rates, measured by the number of pages viewed and the number of comments, were higher in the first month. Higher participation in our study could probably be explained by the fact that two blog posts were published before the study onset so that participants would enter the study and find an active blog. The challenge, as identified by Williams et al [26], is to maintain adherence and keep the participants engaged. However, unlike studies included in this review, we did not find a decrease in usage throughout the intervention period. This could have been due to selection of the intervention components that led to a sustained interest from participants. The fact that we responded to all comments posted on the blog by participants in a timely fashion might have helped to optimize participation.

Participants in our preliminary study [38], and in other studies as well [27,56], mentioned that receiving an email when a new post was published was a useful reminder to engage with the blog. A review examining mobile health interventions for lifestyle behavior changes mentioned that reminders can improve adherence to behavioral goals [57]. This, along with reminders sent to participants who did not log on to the blog for two consecutive weeks, could have helped maintain adherence to the intervention.

We did not have a criterion for the number of comments on the blog, but compared to existing blogs, the participation rate was very high [58]. The fact that comments were posted anonymously (participants were named Blog-pilot X) could

have encouraged participants to publish comments without apprehensions regarding privacy [59]. Using a narrative approach and asking a question to blog readers at the end of all posts could have positively influenced interaction [38,60].

Only a few people watched published videos (16% for video 1 and 11% for video 2). This is consistent with findings from Strekalova et al [61], who concluded that messages with photos are more effective than videos for encouraging public engagement on Facebook. In our preliminary study [38], 45% (15/33) of women mentioned that videos could be useful; however, 27% (9/33) thought they were not very relevant and 30% (10/33) mentioned not having enough time to watch them. In a RCT comparing a video and text version of a Web-based computer-tailored intervention for obesity prevention, the video version was the most effective intervention and most appreciated [62]. Therefore, videos could prove useful for reaching a certain portion of the population, for instance less-educated people who could have a lower literacy level [63], so blog interventions could be adapted according to the target audience. Because videos were not popular in this pilot study, we will not include them in the future RCT.

Attrition Rate

Attrition rate was very low (3%, 2/80). This could be due to the honorarium given to participants in both the control group and healthy eating blog group at the end of the study (Can $100). We also think that this study did not imply much time and involvement because participants could log on to the blog from home and were not forced to write comments and interact with the dietitian-blogger or other participants. A recent study examined the feasibility of delivering a group Web-based and face-to-face weight-loss intervention to 40 young adults with low income and reported that 30% of participants completed the 5-month intervention [56]. This attrition is high, and higher numbers have been observed in other Web-based weight-loss interventions [64,65]. A systematic review of 12 computer-tailored dietary behavior change interventions identified some commonalities between the five studies with higher retention rates: “all used highly motivated and/or self-select samples; a majority were intended as multiple exposure interventions ranging from two to six months and a majority offered incentives to participants” [53].

Limitations of the Study

Our sample may not be representative of the general population. According to a 2014 report by the Pew Research Center, users of social media in the United States are predominantly aged between 18 and 34 years [66]. Also, a cross-sectional survey on health-related communication trends and practices concluded that a significant linear relationship was observed between younger age and blogging site participation [19]. Our sample had a mean age of 42.0 (SD 13.7) years, which is older than what is observed for users of social media. Posting an ad on the personal Facebook page of the research team members may have created a bias due to the demographics of the research team; a more active Facebook or Twitter recruitment could have helped to recruit younger people [67]. Moreover, participants in our study were mostly white, well educated (college or more), and had a relatively high family income. According to a survey conducted by the Pew Research Center in 2014, the majority of adults who are active on social media platforms have a family income less than US $30,000 [68]. In order to reach a more diverse audience, other recruitment methods for the RCT, such as posting an ad in local newspapers and in community centers, should be considered.

Finally, we faced some difficulties in obtaining records of log-ins. Depending on the WordPress updates (the Web software used to create the blog), we noticed that statistics were erroneous for a small number of participants whose log-in statistics were not recorded for some posts, although they had commented on these same posts. This is why we chose to focus on the number of comments and the number of page views to assess participation rates, and not the number of log-ins, which was a less reliable statistic.

Conclusion

This feasibility study provided valuable information about how to optimize and implement a healthy eating blog intervention. It also contributed to inform the conduct of a future definitive RCT to assess the efficacy of a healthy eating blog to improve dietary and eating behaviors. Because preestablished feasibility criteria were met, characteristics of the intervention to be used in the RCT will remain unchanged. Given the novelty of this intervention, this project paves the way for designing and evaluating the effects of other social media tools on consumers’ health outcomes. This study was the first to provide an empirically supported basis for the design of interventions using social media, more specifically blogs, to improve the quality of health promotion and disease prevention health care services through enhanced bidirectional exchange of evidence-based and experiential nutrition-related knowledge.

To date, there is very modest evidence that interventions using online social media may be effective. Because the Web is used more and more and this field of research is very recent [29], more research is needed to determine the effects of a blog on dietary and eating behaviors.

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Authors' Contributions

MEC wrote a first draft of this paper. SD, VBM, VP, MPG, and SS designed the study. MEC and VBM developed the blog content under the supervision of SD and VP, VBM kept a weekly record of log-in statistics, and MEC answered participants' questions and comments. All authors reviewed the manuscript.

Conflicts of Interest

None declared.

References

1. World Health Organization. 2014 Jul. Noncommunicable diseases country profiles 2014 URL: http://www.who.int/nmh/publications/ncd-profiles-2014/en/ [WebCite Cache ID 6k0Ul9Ltp]
2. American Heart Association Nutrition Committee, Lichtenstein AH, Appel LJ, Brands M, Carnethon M, Daniels S, et al. Diet and lifestyle recommendations revision 2006: a scientific statement from the American Heart Association Nutrition Committee. Circulation 2006 Jul 4;114(1):82-96 [FREE Full text] [doi: 10.1161/CIRCULATIONAHA.106.176158] [Medline: 16785338]
3. American Diabetes Association, Bantle JP, Wylie-Rosett J, Albright AL, Apovian CM, Clark NG, et al. Nutrition recommendations and interventions for diabetes: a position statement of the American Diabetes Association. Diabetes Care 2008 Jan;31 Suppl 1:S61-S78. [doi: 10.2337/dc08-S061] [Medline: 18165339]
4. Kushi LH, Doyle C, McCullough M, Rock CL, Demark-Wahnefried W, Bandera EV, American Cancer Society 2010 Nutrition and Physical Activity Guidelines Advisory Committee. American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. CA Cancer J Clin 2012;62(1):30-67 [FREE Full text] [doi: 10.3322/caac.20140] [Medline: 22237782]
5. Garriguet D. Health Reports. Ottawa, ON: Statistics Canada; 2009 Sep. Diet quality in Canada URL: http://www.statcan.gc.ca/access_acces/archive.action?loc=/pub/82-003-x/2009003/article/10914-eng.pdf&archive=1 [accessed 2015-05-21] [WebCite Cache ID 6k0Uc9SJ9]
6. Wantland DJ, Portillo CJ, Holzemer WL, Slaughter R, McGhee EM. The effectiveness of Web-based vs non-Web-based interventions: a meta-analysis of behavioral change outcomes. J Med Internet Res 2004 Nov 10;6(4):e40 [FREE Full text] [doi: 10.2196/jmir.6.4.e40] [Medline: 15631964]
7. Michels KB, Giovannucci E, Chan AT, Singhania R, Fuchs CS, Willett WC. Fruit and vegetable consumption and colorectal adenomas in the nurses' health study. Cancer Res 2006 Apr 03;66(7):3942-3953. [doi: 10.1158/0008-5472.can-05-3637]
8. Stewart Ralph A H, Wallentin L, Benatar J, Danchin N, Hagström E, Held C, et al. Dietary patterns and the risk of major adverse cardiovascular events in a global study of high-risk patients with stable coronary heart disease. Eur Heart J 2016 Jul 1;37(25):1993-2001 [FREE Full text] [doi: 10.1093/eurheartj/ehw125] [Medline: 27109584]
9. World Health Organization. Diet, nutrition and the prevention of chronic disease: report of a joint WHO/FAO expert consultation. Geneva: World Health Organization; 2002. URL: http://www.who.int/dietphysicalactivity/publications/trs916/download/en/ [accessed 2016-03-02] [WebCite Cache ID 6k0V6eb1t]
10. Health Canada. 2011. Eating well with Canada's Food Guide URL: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php [accessed 2016-08-24] [WebCite Cache ID 6k0V02UkA]
11. Statistique Canada. 2015. Consommation de fruits et de légumes, 2014 URL: http://www.statcan.gc.ca/pub/82-625-x/2015001/article/14182-fra.htm [accessed 2016-08-24] [WebCite Cache ID 6k0UukyzB]
12. Slavin JL, Lloyd B. Health benefits of fruits and vegetables. Adv Nutr 2012 Jul;3(4):506-516 [FREE Full text] [doi: 10.3945/an.112.002154] [Medline: 22797986]
13. Food and Agriculture Organization of the United Nations. 2003. Increasing fruit and vegetable consumption becomes a global priority URL: http://www.fao.org/english/newsroom/focus/2003/fruitveg1.htm [accessed 2016-08-10] [WebCite Cache ID 6k0VESPLS]
14. Kimmons J, Gillespie C, Seymour J, Serdula M, Blanck HM. Fruit and vegetable intake among adolescents and adults in the United States: percentage meeting individualized recommendations. Medscape J Med 2009;11(1):26. [Medline: 19295947]
15. World Health Organization. 2003. Adherence to long-term therapies: evidence for action URL: http://www.who.int/chp/knowledge/publications/adherence_report/en/ [accessed 2017-04-04] [WebCite Cache ID 6pTaOhLQ1]
16. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. Health Psychol 2009 Nov;28(6):690-701. [doi: 10.1037/a0016136] [Medline: 19916637]
17. Shaikh AR, Yaroch AL, Nebeling L, Yeh M, Resnicow K. Psychosocial predictors of fruit and vegetable consumption in adults a review of the literature. Am J Prev Med 2008 Jun;34(6):535-543. [doi: 10.1016/j.amepre.2007.12.028] [Medline: 18471592]
18. Guillaumie L, Godin G, Vézina-Im L. Psychosocial determinants of fruit and vegetable intake in adult population: a systematic review. Int J Behav Nutr Phys Act 2010;7:12 [FREE Full text] [doi: 10.1186/1479-5868-7-12] [Medline: 20181070]

19. Chou WS, Hunt YM, Beckjord EB, Moser RP, Hesse BW. Social media use in the United States: implications for health communication. J Med Internet Res 2009;11(4):e48 [FREE Full text] [doi: 10.2196/jmir.1249] [Medline: 19945947]
20. Suggs LS. A 10-year retrospective of research in new technologies for health communication. J Health Commun 2006;11(1):61-74. [doi: 10.1080/10810730500461083] [Medline: 16546919]
21. Wikipedia. Blog URL: https://en.wikipedia.org/wiki/Blog [accessed 2016-08-24] [WebCite Cache ID 6k0VKWvF5]
22. Vance K, Howe W, Dellavalle RP. Social internet sites as a source of public health information. Dermatol Clin 2009 Apr;27(2):133-136, vi. [doi: 10.1016/j.det.2008.11.010] [Medline: 19254656]
23. Norman CD, McIntosh S, Selby P, Eysenbach G. Web-assisted tobacco interventions: empowering change in the global fight for the public's (e)Health. J Med Internet Res 2008;10(5):e48 [FREE Full text] [doi: 10.2196/jmir.1171] [Medline: 19033147]
24. Lefebvre R. The new technology: the consumer as participant rather than target audience. Soc Market Quart 2007 Sep 01;13(3):31-42. [doi: 10.1080/15245000701544325]
25. Eysenbach G. The law of attrition. J Med Internet Res 2005;7(1):e11 [FREE Full text] [doi: 10.2196/jmir.7.1.e11] [Medline: 15829473]
26. Williams G, Hamm MP, Shulhan J, Vandermeer B, Hartling L. Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials. BMJ Open 2014;4(2):e003926 [FREE Full text] [doi: 10.1136/bmjopen-2013-003926] [Medline: 24525388]
27. Brouwer W, Kroeze W, Crutzen R, de Nooijer J, de Vries NK, Brug J, et al. Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review. J Med Internet Res 2011;13(1):e2 [FREE Full text] [doi: 10.2196/jmir.1639] [Medline: 21212045]
28. Kohl LF, Crutzen R, de Vries NK. Online prevention aimed at lifestyle behaviors: a systematic review of reviews. J Med Internet Res 2013 Jul;15(7):e146 [FREE Full text] [doi: 10.2196/jmir.2665] [Medline: 23859884]
29. Maher CA, Lewis LK, Ferrar K, Marshall S, De Bourdeaudhuij I, Vandelanotte C. Are health behavior change interventions that use online social networks effective? A systematic review. J Med Internet Res 2014;16(2):e40 [FREE Full text] [doi: 10.2196/jmir.2952] [Medline: 24550083]
30. Lancaster GA, Dodd S, Williamson PR. Design and analysis of pilot studies: recommendations for good practice. J Eval Clin Pract 2004 May;10(2):307-312. [doi: 10.1111/j.2002.384.doc.x] [Medline: 15189396]
31. Browne RH. On the use of a pilot sample for sample size determination. Stat Med 1995 Sep 15;14(17):1933-1940. [Medline: 8532986]
32. Thabane L, Ma J, Chu R, Cheng J, Ismaila A, Rios LP, et al. A tutorial on pilot studies: the what, why and how. BMC Med Res Methodol 2010;10:1 [FREE Full text] [doi: 10.1186/1471-2288-10-1] [Medline: 20053272]
33. Lake A, Hyland R, Rugg-Gunn AJ, Wood CE, Mathers JC, Adamson A. Healthy eating: perceptions and practice (the ASH30 study). Appetite 2007 Mar;48(2):176-182. [doi: 10.1016/j.appet.2006.08.065] [Medline: 17113681]
34. Flagg LA, Sen B, Kilgore M, Locher JL. The influence of gender, age, education and household size on meal preparation and food shopping responsibilities. Public Health Nutr 2014 Sep;17(9):2061-2070 [FREE Full text] [doi: 10.1017/S1368980013002267] [Medline: 23988018]
35. Wright S, Page E. LinkedIn SlideShare. 2009. 2009 women and social media study by BlogHer, iVillage and Compass Partners URL: http://fr.slideshare.net/LisaStone/2009-women-and-social-media-study-by-blogher-ivillage-and-compass-partners [accessed 2016-08-24] [WebCite Cache ID 6k0VXaU4V]
36. Lynch M. Healthy habits or damaging diets: an exploratory study of a food blogging community. Ecol Food Nutr 2010;49(4):316-335. [doi: 10.1080/03670244.2010.491054] [Medline: 21888474]
37. Simunaniemi A, Sandberg H, Andersson A, Nydahl M. Laypeople blog about fruit and vegetables for self-expression and dietary influence. Health Commun 2011 Oct;26(7):621-630. [doi: 10.1080/10410236.2011.561520] [Medline: 21541865]
38. Bissonnette-Maheux V, Provencher V, Lapointe A, Dugrenier M, Dumas A, Pluye P, et al. Exploring women's beliefs and perceptions about healthy eating blogs: a qualitative study. J Med Internet Res 2015;17(4):e87 [FREE Full text] [doi: 10.2196/jmir.3504] [Medline: 25858777]
39. Godin G. Les Comportements dans le Domaine de la Santé: Comprendre pour Mieux Intervenir. Montréal: Les Presses du l'Université de Montréal; Nov 2012:328.
40. Government of Canada. 2015. Tips for healthy eating URL: http://healthycanadians.gc.ca/eating-nutrition/healthy-eating-saine-alimentation/tips-conseils/index-eng.php [accessed 2016-08-24] [WebCite Cache ID 6k0Vja8W7]
41. Region of Waterloo Public Health and Emergency Services. 2015. Food skills of Waterloo region adults URL: http://chd.region.waterloo.on.ca/en/healthylivinghealthprotection/foodskills.asp [accessed 2016-08-24] [WebCite Cache ID 6k0VpctqA]
42. World Health Organization. 2013. Global action plan for the prevention and control of NCDs 2013-2020 URL: http://www.who.int/nmh/events/ncd_action_plan/en/ [accessed 2016-08-24] [WebCite Cache ID 6k0W3cpoI]
43. Michie S, Ashford S, Sniehotta FF, Dombrowski SU, Bishop A, French DP. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. Psychol Health 2011 Nov;26(11):1479-1498. [doi: 10.1080/08870446.2010.540664] [Medline: 21678185]

44. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker A. Making psychological theory useful for implementing evidence based practice: a consensus approach. Qual Saf Health Care 2005 Feb;14(1):26-33 [FREE Full text] [doi: 10.1136/qshc.2004.011155] [Medline: 15692000]
45. Albada A, van Dulmen S, Otten R, Bensing J, Ausems MG. Development of E-info gene(ca): a website providing computer-tailored information and question prompt prior to breast cancer genetic counseling. J Genet Couns 2009 Aug;18(4):326-338. [doi: 10.1007/s10897-009-9221-4] [Medline: 19440661]
46. de Bruin M, Viechtbauer W, Hospers HJ, Schaalma HP, Kok G. Standard care quality determines treatment outcomes in control groups of HAART-adherence intervention studies: implications for the interpretation and comparison of intervention effects. Health Psychol 2009 Nov;28(6):668-674. [doi: 10.1037/a0015989] [Medline: 19916634]
47. Lohman T, Roche A, Martorell R. Standardization of anthropometric measurements. In: Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics Books; 1988:39-80.
48. Labonté M, Cyr A, Baril-Gravel L, Royer M, Lamarche B. Validity and reproducibility of a web-based, self-administered food frequency questionnaire. Eur J Clin Nutr 2012 Feb;66(2):166-173. [doi: 10.1038/ejcn.2011.163] [Medline: 21934698]
49. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. J Psychosom Res 1985;29(1):71-83. [Medline: 3981480]
50. Allison DB, Kalinsky LB, Gorman BS. A comparison of the psychometric properties of three measures of dietary restraint. Psychol Assess 1992;4(3):391-398. [doi: 10.1037/1040-3590.4.3.391]
51. Tylka TL. Development and psychometric evaluation of a measure of intuitive eating. J Counsel Psychol 2006;53(2):226-240. [doi: 10.1037/0022-0167.53.2.226]
52. Lapointe A, Weisnagel SJ, Provencher V, Bégin C, Dufour-Bouchard A, Trudeau C, et al. Using restrictive messages to limit high-fat foods or nonrestrictive messages to increase fruit and vegetable intake: what works better for postmenopausal women? Eur J Clin Nutr 2010 Feb;64(2):194-202. [doi: 10.1038/ejcn.2009.135] [Medline: 19935818]
53. Neville LM, O'Hara B, Milat AJ. Computer-tailored dietary behaviour change interventions: a systematic review. Health Educ Res 2009 Aug;24(4):699-720 [FREE Full text] [doi: 10.1093/her/cyp006] [Medline: 19286893]
54. Health Canada. Canadian guidelines for body weight classification in adults URL: http://www.hc-sc.gc.ca/fn-an/nutrition/weights-poids/guide-ld-adult/cg_quick_ref-ldc_rapide_ref-eng.php [accessed 2016-08-24] [WebCite Cache ID 6k0Wf2sTl]
55. Neve M, Morgan PJ, Jones PR, Collins CE. Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. Obes Rev 2010 Apr;11(4):306-321. [doi: 10.1111/j.1467-789X.2009.00646.x] [Medline: 19754633]
56. Cavallo DN, Sisneros JA, Ronay AA, Robbins CL, Jilcott Pitts SB, Keyserling TC, et al. Assessing the feasibility of a web-based weight loss intervention for low-income women of reproductive age: a pilot study. JMIR Res Protoc 2016;5(1):e30 [FREE Full text] [doi: 10.2196/resprot.4865] [Medline: 26920252]
57. Piette JD, List J, Rana GK, Townsend W, Striplin D, Heisler M. Mobile health devices as tools for worldwide cardiovascular risk reduction and disease management. Circulation 2015 Nov 24;132(21):2012-2027. [doi: 10.1161/CIRCULATIONAHA.114.008723] [Medline: 26596977]
58. Fox S. Pew Research Center. 2011 May 12. The social life of health information, 2011 URL: http://www.pewinternet.org/2011/05/12/the-social-life-of-health-information-2011 [accessed 2016-08-24] [WebCite Cache ID 6k0WiCHys]
59. Shan LC, Panagiotopoulos P, Regan A, de Brun A, Barnett J, Wall P, et al. Interactive communication with the public: qualitative exploration of the use of social media by food and health organizations. J Nutr Educ Behav 2015;47(1):104-108. [doi: 10.1016/j.jneb.2014.09.004] [Medline: 25449827]
60. Lu AS. An experimental test of the persuasive effect of source similarity in narrative and nonnarrative health blogs. J Med Internet Res 2013;15(7):e142 [FREE Full text] [doi: 10.2196/jmir.2386] [Medline: 23887135]
61. Strekalova YA, Krieger JL. A picture really is worth a thousand words: public engagement with the National Cancer Institute on social media. J Cancer Educ 2015 Sep 8. [doi: 10.1007/s13187-015-0901-5] [Medline: 26351003]
62. Walthouwer MJ, Oenema A, Lechner L, de Vries H. Comparing a video and text version of a web-based computer-tailored intervention for obesity prevention: a randomized controlled trial. J Med Internet Res 2015;17(10):e236 [FREE Full text] [doi: 10.2196/jmir.4083] [Medline: 26481772]
63. Adams SA. Revisiting the online health information reliability debate in the wake of “web 2.0”: an inter-disciplinary literature and website review. Int J Med Inform 2010 Jun;79(6):391-400. [doi: 10.1016/j.ijmedinf.2010.01.006] [Medline: 20188623]
64. Brindal E, Freyne J, Saunders I, Berkovsky S, Smith G, Noakes M. Features predicting weight loss in overweight or obese participants in a web-based intervention: randomized trial. J Med Internet Res 2012;14(6):e173 [FREE Full text] [doi: 10.2196/jmir.2156] [Medline: 23234759]
65. Kelders SM, Van Gemert-Pijnen JE, Werkman A, Nijland N, Seydel ER. Effectiveness of a Web-based intervention aimed at healthy dietary and physical activity behavior: a randomized controlled trial about users and usage. J Med Internet Res 2011;13(2):e32 [FREE Full text] [doi: 10.2196/jmir.1624] [Medline: 21493191]
66. Pew Research Center. 2013 Dec 27. Social networking fact sheet URL: http://www.pewinternet.org/fact-sheets/social-networking-fact-sheet/ [accessed 2016-06-15] [WebCite Cache ID 6k0WnuZAz]

67. Nolte MT, Shauver MJ, Chung KC. Analysis of four recruitment methods for obtaining normative data through a Web-based questionnaire: a pilot study. Hand (N Y) 2015 Sep;10(3):529-534. [doi: 10.1007/s11552-014-9730-y] [Medline: 26330790]
68. Duggan M, Brenner J. Pew Research Center. 2013 Feb 14. Social networking site users URL: http://www.pewinternet.org/2013/02/14/social-networking-site-users/ [accessed 2016-08-24] [WebCite Cache ID 6k0XBLkNM]

Abbreviations

BMI: body mass index
FFQ: food frequency questionnaire
INAF: Institute of Nutrition and Functional Foods
RCT: randomized controlled trial

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Original Paper

Using Mobile Phones to Collect Patient Data: Lessons Learned From the SIMPle Study

Sinead Duane[1], PhD, MBS, B A; Meera Tandan[1], MPH; Andrew W Murphy[1], MD, MClinEpi; Akke Vellinga[1], PhD, MEpi, MSc

Discipline of General Practice, National University of Ireland Galway, Galway, Ireland

Corresponding Author:
Sinead Duane, PhD, MBS, B A
Discipline of General Practice
National University of Ireland Galway
1 Distillery Road
Galway,
Ireland
Phone: 353 91493855
Fax:
Email: sinead.duane@nuigalway.ie

Abstract

Background: Mobile phones offer new opportunities to efficiently and interactively collect real-time data from patients with acute illnesses, such as urinary tract infections (UTIs). One of the main benefits of using mobile data collection methods is automated data upload, which can reduce the chance of data loss, an issue when using other data collection methods such as paper-based surveys.

Objective: The aim was to explore differences in collecting data from patients with UTI using text messaging, a mobile phone app (UTI diary), and an online survey. This paper provides lessons learned from integrating mobile data collection into a randomized controlled trial.

Methods: Participants included UTI patients consulting in general practices that were participating in the Supporting the Improvement and Management of UTI (SIMPle) study. SIMPle was designed to improve prescribing antimicrobial therapies for UTI in the community. Patients were invited to reply to questions regarding their UTI either via a prospective text message survey, a mobile phone app (UTI diary), or a retrospective online survey. Data were collected from 329 patients who opted in to the text message survey, 71 UTI patients through the mobile phone UTI symptom diary app, and 91 online survey participants.

Results: The age profile of UTI diary app users was younger than that of the text message and online survey users. The largest dropout for both the text message survey respondents and UTI diary app users was after the initial opt-in message; once the participants completed question 1 of the text message survey or day 2 in the UTI diary app, they were more likely to respond to the remaining questions/days.

Conclusions: This feasibility study highlights the potential of using mobile data collection methods to capture patient data. As well as improving the efficiency of data collection, these novel approaches highlight the advantage of collecting data in real time across multiple time points. There was little variation in the number of patients responding between text message survey, UTI diary, and online survey, but more patients participated in the text message survey than the UTI diary app. The choice between designing a text message survey or UTI diary app will depend on the age profile of patients and the type of information the researchers' desire.

Trial Registration: ClinicalTrials.gov NCT01913860; https://clinicaltrials.gov/ct2/show/NCT01913860 (Archived by WebCite at http://www.webcitation.org/6pfgCztgT).

(JMIR Res Protoc 2017;6(4):e61) doi:10.2196/resprot.6389

KEYWORDS

mobile phone apps; mobile survey; antimicrobial resistance; primary care; quantitative; prescribing; urinary tract infection

Introduction

Paper-based surveys have been the standard for collecting patient data in health research. This data collection method is limited due to issues related to data entry and storage costs. Mobile phones offer new opportunities to collect real-time data in a much more efficient and interactive way including automated data upload without data loss, which can be an issue when using other data collection methods [1]. Mobile phones have already been used successfully in the past in the development of health and behavioral change interventions. Examples include in the areas of diabetes self-management, weight loss, physical activity, smoking cessation, and medication adherence [2].

Text messaging or short message service (SMS) has become a ubiquitous method of communication displacing more traditional landline infrastructures [3]. In 2009, Irish citizens were the second-highest users of SMS text messaging in Europe, sending an average of 2700 text messages per year [4]. In 2010, there were an estimated 5.5 million mobile phone subscriptions in Ireland equating to a mobile phone penetration of 119% [5]. Text messaging is fast and convenient giving users flexibility to respond at any time or place and presenting new opportunities to evaluate health-related interventions. The use of automated text messaging services for evaluating health interventions is growing.

According to a recent survey, 75% of people in Ireland are mobile phone users [6]. In 2009, worldwide mobile app downloads amounted to approximately 2.52 billion and are expected to reach 268.69 billion in 2017 [7]. Mobile phones offer researchers new data collection opportunities due to the way in which they are used and how data are shared. Mobile phone apps can reduce data management and processing time for researchers; however, technical difficulties are considered a disadvantage [8]. Mobile phones have been used in the self-management of health and as an adaptive learning, sharing, and social support platform for individuals [9]. However, only recently have apps been used to capture data related to health for the purposes of scientific research. One of the first initiatives in this direction has recently been launched by Apple, who introduced a mobile platform for biomedical research to boost large-scale health studies [10]. Mobile apps are transforming how medicine is conducted and taught in the health care setting [11]; however, there is little evidence of how they can be used to rigorously monitor patient outcomes. To our knowledge, no study has captured real-time data from patients to record urinary tract infection (UTI) symptoms and treatment using a mobile phone app.

This is the also the first time SMS text messaging and mobile phone apps have been used as part of an evaluation of a complex intervention. This paper explores the feasibility of using novel mobile data collection methods to enhance evaluation of complex interventions. This paper illustrates how patient data were collected via a text messaging survey, mobile phone symptom diary app, and retrospective online questionnaire within the Supporting the Improvement and Management of UTI (SIMPle) study. It concludes by discussing the lessons learned from adopting these novel approaches and the potential implications.

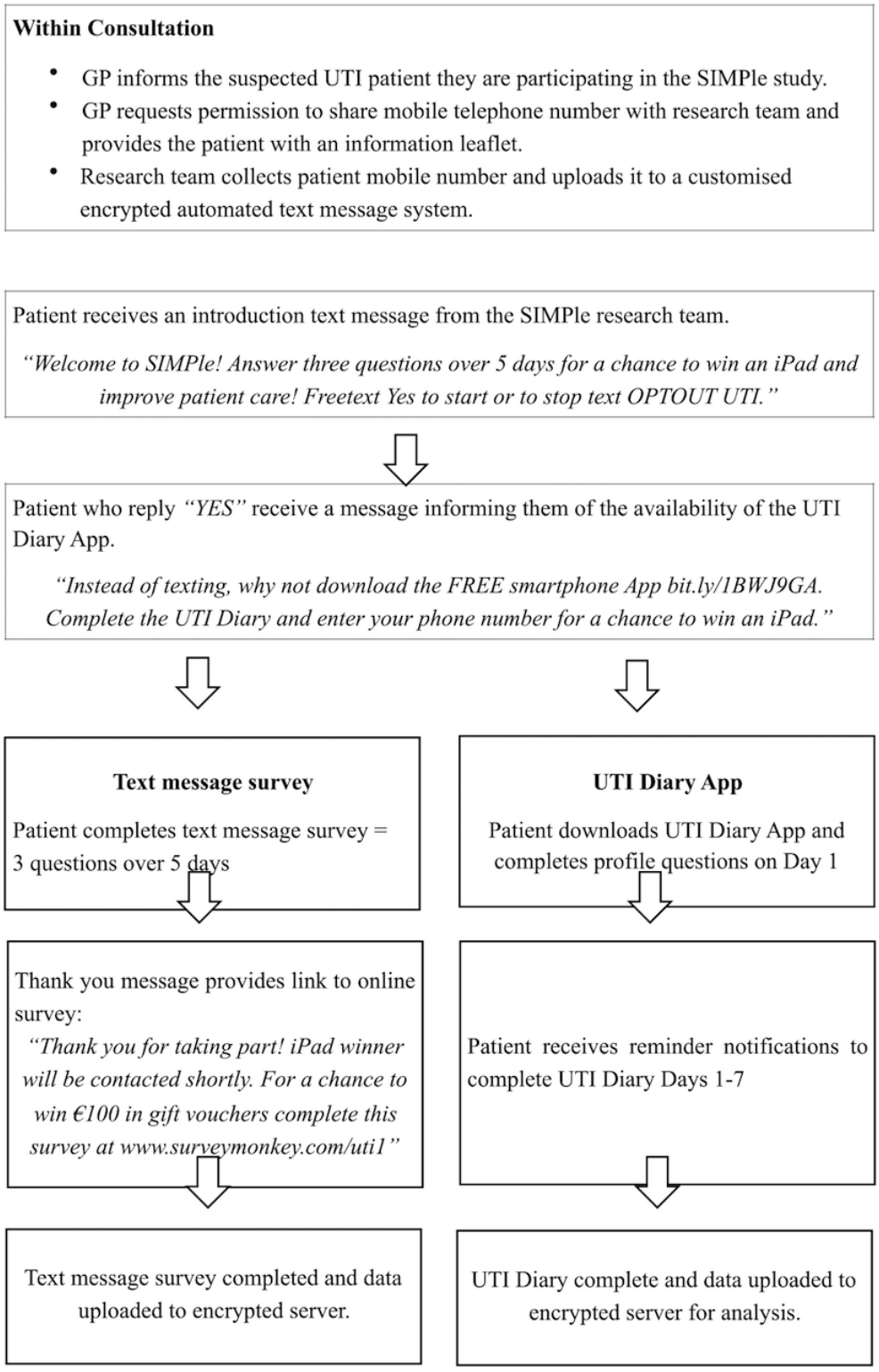
Methods

Procedure

Data were collected from UTI patients through text message survey, a mobile phone symptom diary app (UTI diary), and an online survey. UTIs are the second-most common infections presenting in primary care. Symptoms include feeling unwell, frequency and urgency of urination, pain when passing urine, and pain in the lower abdomen [12]. General practitioners (GPs) from 30 practices participating in the SIMPle study [13] were asked to invite patients with suspected UTI to provide their mobile phone number to the research team. Figure 1 summarizes how the data were collected. Ethical approval was granted for this study through the Irish College of General Practitioners research ethics committee.

The research team initiated contact with UTI patients via text message. The first text message confirmed consent before further participation. Patients who replied “yes” (indicating consent) were invited to complete a text message survey or download the UTI diary app. Patients who completed the text message survey were sent a link to an online survey once they had responded to three questions over five days.

Figure 1. Data collection procedures for the SIMPIe study.



Text Message Survey

The text message survey was designed to capture data from patients on the type of treatment they recieved, when they started antimicrobial treatment (if at all), and the duration of symptoms. The text message workflow was designed using a customized process that included a 24-hour delay between each question. Text messages were sent at noon each day. Each question used a different keyword (yes, UTI, start, day, and optout UTI). These keywords were used to differentiate responses to each of the questions. Questions were limited to 160 characters including spaces, keywords, response options, and opt-out instructions. An example of one of the questions was: " Did the GP give you a) antibiotic prescription b) antibiotic prescription & asked to wait 2 days c) other. Freetext UTI & the answer (eg UTI a) or OPTOUT UTI." All messages were free to send and receive

and patients could opt out of the process at any stage. Text messages were pretested for comprehension.

Urinary Tract Infection Diary App

The UTI diary app and online survey focused on examining the type of symptoms, severity of symptoms, and treatment recommended. Questions were developed from previous international qualitative and quantitative studies and further expert opinion. Both the UTI diary app and online survey were pretested to ensure face validity of measures and usability.

The UTI diary app captured data in "real time" over 7 days (days 1-5 and day 7; Figure 2). The UTI diary app was compatible with Android and iOS (Apple) platforms. On downloading the UTI diary app (day 1), participants completed profile questions (age, gender, employment status), general health, severity of symptoms, and outlined the type of treatment the GP recommended. On days 2 to 5, the same two questions were repeated: severity of symptoms (pain scale) and medication taken (if any). On day 7, participants were asked the same questions as days 2 to 5 with three additional questions on symptoms, satisfaction of information provided at the GP consultation, and general health status. The UTI diary app participants received daily reminders to complete their diary entry.

Participants who completed the text message survey and UTI diary were entered into a draw to win an iPad.

Figure 2. Screenshots of the UTI diary app.

Online Survey

The online survey was completed approximately 5 days after the UTI consultation via SurveyMonkey. The online survey was much longer than the UTI diary and included 23 questions on patient satisfaction with the consultation, type and severity of symptoms, treatment, and demographics. The online survey included more extensive scales on patient satisfaction and patient demographics, for example. Online survey participants were entered into a draw to win €120 of vouchers.

Data Management and Analysis

Data from the text message survey and UTI diary app were remotely uploaded and transferred to a secure password-encrypted database. Online survey data were downloaded from the SurveyMonkey database. Missing data were coded prior to analysis. The text message survey, UTI diary app, and online survey were analyzed separately. The data were analyzed to describe participants' demographic characteristics and symptoms and severity experienced. All participants' answers were automatically entered into a data file, which was checked for accuracy by two independent researchers.

Data are presented as frequencies and univariate analysis was performed using chi-square tests (at $P \leq .05$, 95% confidence interval) to identify variables associated with antimicrobial prescribing among UTI diary app users only. To evaluate if antimicrobials improved the speed of recovery, a variable was created to indicate the day on which they were considered improved (set at level 2 or less on the pain scale and a second analysis was performed with level 3 or less). Based on this outcome, a Cox proportional hazards model with antimicrobial prescription as an independent predictor was calculated. Data were analyzed using SPSS version 21.0.

Results

Participants and Sample

During the SIMPle intervention period (9 months), 2264 patients were coded U71 in the GP patient management software, meaning these patients were identified as patients with UTIs [14]. GPs were asked to submit a urine sample to the laboratory for all patients who they coded as U71; patient mobile phone numbers were written on the urine sample form and collected by the researchers. During the intervention period, a urine sample was obtained and sent to the laboratory from 1286 patients or approximately 50% of index consultations. A total of 941 mobile phone numbers were collected from these urine sample forms and these patients were sent an invitation text message to participate in the text message survey. Of these, 351 (37.3%) patients responded to the initial invitation to participate in the text message survey. Twenty-two participants were

excluded from analysis due to missing data; therefore, a total of 329 participants answered question 1 of the text message survey. The UTI diary app was downloaded 203 times (175 iOS users and 28 Android users) over a 6-month period. Of participants who downloaded the UTI diary app, 71 (35.0%) responded of whom 31 completed the 7 days of the UTI diary app. Of the 261 who completed the text message survey, 91 (34.9%) responded to the online survey (Figure 3).

Figure 3. Summary of sampling frame.

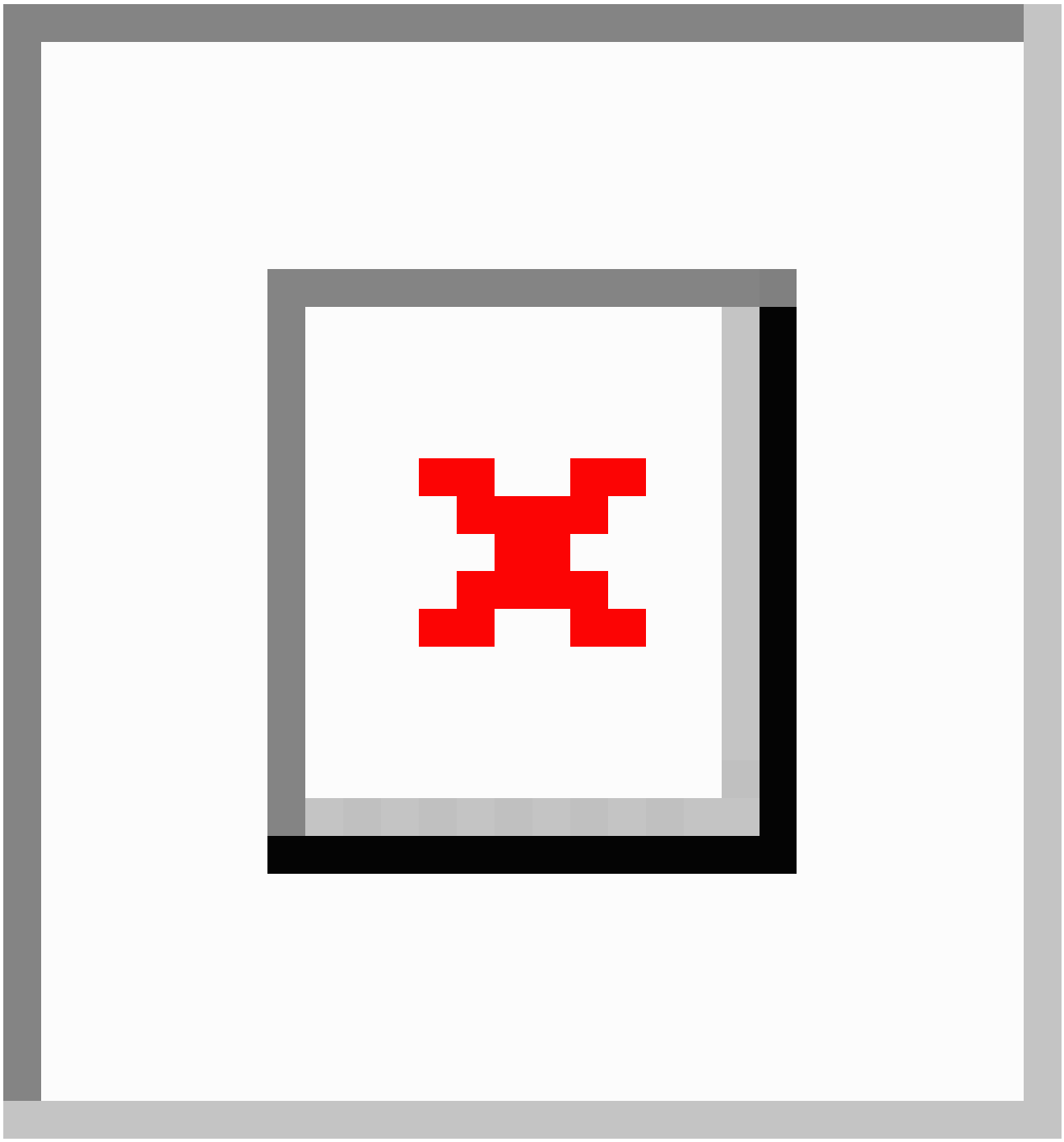


Table 1. Demographic characteristics of participants (N=491).

Characteristics	Text message survey, n (%) (n=329)	UTI diary app, n (%) (n=71)	Online survey, n (%) (n=91)
Age (years)			
18-24	34 (10.3)	30 (42)	13 (14)
25-34	62 (18.8)	18 (25)	23 (25)
35-44	63 (1901)	13 (18)	28 (31)
45-54	64 (19.5)	6 (9)	13 (14)
>55	106 (32)	4 (6)	14 (15)
Gender			
Male	22 (6.3)	12 (17)	4 (4)
Female	326 (91.7)	59 (83)	87 (96)
Unknown	7 (2)		
Employment			
Employed	—	50 (70)	65 (71)
Unemployed	—	10 (14)	15 (17)
Students	—	11 (16)	11 (12)
Antimicrobials prescribed[a]			
Yes	132 (88)	51 (72)	86 (95)
No	18 (12)	20 (28)	5 (5)

[a] For text message survey, n=150.

Demographic Characteristics

Demographic characteristics of the text message survey, UTI diary app, and online survey participants are provided in Table 1.

Across the three data collection tools, participants were mostly female. The majority of UTI diary app participants were aged between 18 and 34 years (67%, 48/71). This was a much younger age profile than those completing the text message survey (28.6%, 94/329) and online participants (40%, 36/91) for the same age group. Those older than 35 years represented 32% (23/71) in UTI diary app group, 71.1% (234/329) of the text message group, and 60% (55/91) of the online survey group.

The majority of participants received an antimicrobial prescription and this was similar in the UTI diary app group (72%, 51/71) and text messaging group (88.8%, 132/150), but much higher in the online survey group (95%, 86/91).

Text Message Survey Response

The time taken to respond to the text survey varied between participants. For the opt-in message and question 1, more than half of participants responded in less than 1 hour, whereas a further 30% took more than 12 hours to respond. For questions 2 and 3, nearly all participants responded within less than an hour (Q2: 97.5%, 196/201; Q3: 99.5%, 213/214).

Table 2 summarizes the number of times each message was sent before a response was received. The largest dropout from respondents was after the initial opt-in message; once the participant completed question 1, they were more likely to respond to the remaining questions.

The majority of participants who choose to opt out (22.8%, 99/351) did so at the beginning of the process. Nearly 24% did not respond to questions 2 (63/269) and 3 (63/265).

Participants sometimes used incorrect keywords, such as “UTI” instead of the question 2 keyword “start.” When wrong keywords were used, the responses were removed from the analysis.

Table 2. Number of times the text message questions were sent to UTI patients.

Number of times message sent	Opt-in message, n (%) (n=351)	Question 1, n (%) (n=270)	Question 2, n (%) (n=268)	Question 3, n (%) (n=263)	Thank you message, n (%) (n=261)
1	251 (71.5)	154 (57.0)	161 (60.1)	190 (72.2)	261 (100)
2	99 (28.2)	116 (43.0)	100 (37.3)	73 (27.8)	—
3	1 (0.3)	—	4 (1.5)	—	—
4	—	—	2 (0.7)	—	—
5	—	—	1 (0.4)	—	—

Urinary Tract Infection Diary App

Unlike the text message survey, there was no pattern to when people completed the UTI diary. The participants' response times depended on when they downloaded the UTI diary app.

Table 3 summarizes the overall responses for the UTI diary app. Similar to the text message survey, there was a drop off between opting in on day 1 and days 2 to 7. However, Table 3 highlights that once participants completed day 2 they were less likely to drop out of participating in the UTI diary app. Finally, Table 3 also highlights that UTI diary participants did not skip any questions when completing the UTI diary app; therefore, all fields provided the researchers with data.

Despite the relatively low number of responses to the UTI diary app, the potential of this feasibility study is demonstrated in the analysis of the answers.

Urinary Tract Infection Diary Response

Severity of Symptoms

Table 4 compares severity of symptoms reported on day 1 through the UTI diary with the retrospective account of symptoms on day 5 from the online survey. Overall, double the online survey participants (39%, 35/91) retrospectively rated their symptoms to be severe compared to 18% (13/71) of participants providing real-time data through the UTI diary app.

Table 3. Overall number of participants responding to each question in the UTI diary app.

App questions	Day, n (%)					
	1 (n=71)	2 (n=71)	3 (n=46)	4 (n=42)	5 (n=38)	7 (n=33)
Profile questions						
What type of treatment did your GP recommend?	71 (100)	—	—	—	—	—
Gender	71 (100)	—	—	—	—	—
Age	71 (100)	—	—	—	—	—
Number of children	71 (100)	—	—	—	—	—
Work situations	71 (100)	—	—	—	—	—
Health questions						
How good or bad is your health today?	71 (100)	—	—	—	—	—
How is your health in general?	71 (100)	—	—	—	—	—
Overall, how satisfied were you with the treatment recommended by your GP?	71 (100)	—	—	—	—	—
Which of these best describes your symptoms today?	71 (100)	46 (65)	42 (91)	38 (91)	33 (87)	—
What medication have you taken today?	71 (100)	46 (65)	42 (91)	38 (91)	33 (87)	—
Which of the following symptoms (if any) did you experience during your UTI?	—	—	—	—	—	31 (94)
How good or bad is your health today?	—	—	—	—	—	31 (94)
How is your health in general?	—	—	—	—	—	31 (94)
Overall, how satisfied were you with the treatment recommended by your GP?	—	—	—	—	—	31 (94)
How good was your GP at explaining your treatment for your UTI?	—	—	—	—	—	31 (94)

Table 4. Severity of symptoms for real-time participants (app) compared to retrospective participants (online survey).

UTI symptoms rated	UTI diary app, n (%) (n=71)	Online survey, n (%) (n=91)
Mild	28 (39)	6 (7)
Moderate	30 (42)	50 (55)
Severe	13 (18)	35 (39)

Among UTI diary app participants, a significant decrease in severity was observed between day 1 and day 2 (χ^2_1=5.2, *P*=.02; Table 5). Of the participants who indicated worsening of symptoms between days 1 and 2, 64% (21/33) started antimicrobial therapy immediately.

Figure 4 and Table 6 illustrate the severity of symptoms rated by UTI diary app users over 5 days (days 1-5). Irrespective of antimicrobial treatment, patients improved within 1 to 2 days after their GP consultation. When comparing the speed of improvement of the patients who did and did not take antimicrobial therapy, no difference was observed in reaching a score 2 or less on the pain scale. This was similar for reaching a score of 3 or less (Cox proportional hazards not significant).

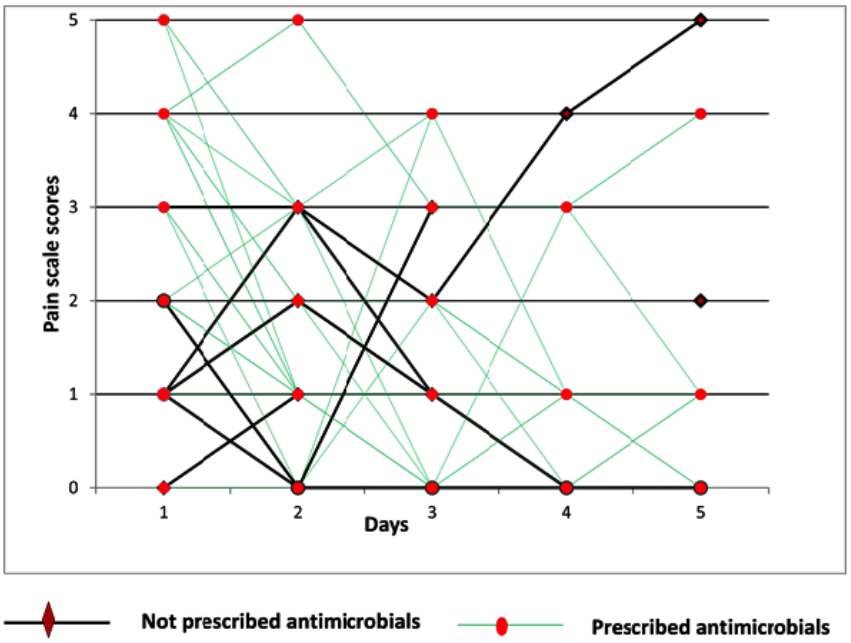
Table 5. Change in the severity of symptoms of the UTI diary app patients from day 1 to day 2.

Severity of symptoms	No antimicrobial prescription (n=13)	Antimicrobial prescription (n=33)	Total (n=46)
Worse	4 (31)	21 (64)	25 (54)
Same	4 (31)	8 (24)	12 (26)
Better	5 (39)	4 (12)	9 (20)

Table 6. The severity of symptoms rated by UTI diary app users over 5 days.

Prescribed antimicrobial therapy	Daily pain scale score, n																								
	Day 1					Day 2					Day 3					Day 4					Day 5				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
No	7	3	4	2		4	2	3			5	1	1			2		1	1		1	1			1
Yes	14	15	8	7	4	17	3	5		1	12	3	1	2		7		2			9				1

Figure 4. Severity symptoms rated by apps participants from days 1 to 5 (n=71).



Discussion

This study shows the feasibility of collecting real-time data through novel mobile data collection methods, such as text messaging and mobile phone apps. These methods have the advantage of collecting data in real time across multiple time points. The respondents of this research were predominantly female, which is reflective of the profile of a UTI patient.

Uptake by Patients

There was little variation in response between text message survey, UTI diary, and online survey, but more patients participated in the text message survey than the UTI diary app. There may be a number of reasons for this observation. Firstly, the profile of the UTI diary app users was younger compared to text message participants. Because the mean age of patients within the SIMPle study was 56.1 (SD 20.7) years [14], this age group may favor text messaging over mobile phone app. Secondly, the researchers were reliant on the GP to obtain patient mobile phone numbers. Post intervention interviews with GPs who participated in SIMPle indicated that some GPs found it difficult to explain to patients why they were requesting their mobile phone numbers, some GPs just forgot to ask patients, whereas others choose not to ask some patients (ie, elderly patients) thereby introducing selection bias. Therefore, not every patient was asked to participate. Thirdly, there was also a delay of one week between the launch of the SIMPle intervention and the availability of the UTI diary app, which meant that many GPs did not receive a demonstration of the UTI diary app. Improving the uptake of any mobile phone app for use in general practice requires full collaboration from the GP to be able to encourage download. Our study missed the buy-in of all GPs due to the delay.

Text Message Design

A total of 351 patients opted in to the text message survey process, which represented a response of 37%. Each text message needed to be 160 characters or less, the researchers were restricted in what they could ask and how questions were presented. This meant that it was difficult to ask validated questions, particularly because each text message was required to contain opt-out instructions.

Questions were organized to follow the natural resolution of UTI and a 24-hour delay was implemented between each question in our survey to allow the resolution of symptoms before the final question. This may not have been clear to participants because some responded a few times to the same questions. An automated thank you message and better communication about the structure of the survey can improve this.

Repeating the question in the case of no response reminded participants to complete the entire series of questions. This strategy seemed to work well and is recommended if text messaging is considered.

Mobile Phone App Design

The design of the UTI diary app allowed the researcher to capture real-time information on the participant and their symptoms over 7 days. Unlike the text message survey, its design was not restricted by character length; however, cost of design may be an issue.

Reminder messages (push notifications) were built into the UTI diary app, but it is unclear if these were helpful for the participants or whether participants turned these off manually.

The potential richness of data available through the UTI diary app was also an important factor when designing this app. The findings from the UTI diary app identified differences in prospective and retrospective reporting of severity of symptoms. Patients recalling severity of symptoms retrospectively (via online survey) were more likely to rate them as severe compared to those who were asked to rate symptoms in real time (via UTI diary app).

Similarly, this feasibility study showed little or no association between type and severity of symptoms and antimicrobial treatment because the majority of patients received an antimicrobial prescription (UTI diary app: 72%, 51/71; online survey: 95%, 86/91). Most patients seem to visit their GP around the peak of symptom severity. Irrespective of treatment, most patients improved within one or at the most two days. This seems to suggest that symptoms improve before the antimicrobial treatment can have an effect, which is suggested to take 24 to 48 hours. Although the sample size is too small to draw conclusions from this data, it highlights avenues for further research. These issues should be further examined in the randomized controlled trial (RCT) setting where the combination of the UTI diary app within an RCT comparing antimicrobial and symptomatic treatment will provide further insight.

Data Analysis

All data were automatically uploaded to an encrypted server that the researcher could access. This made the analysis process more efficient and because data were received in real time the researchers could observe the uptake of the various data collection methods.

To our knowledge, no other studies have captured data on patient symptoms, treatment, and duration of symptoms using a text message survey or mobile phone app. The UTI diary app captured data in real time allowing researchers to track the progression of a UTI from consultation to when participants were symptom-free.

Data presented in this feasibility study are limited and results should guide further research. However, even though sample size was limited, the results are intuitive; real-time data can be used to capture a greater understanding of actual severity and symptoms compared to other methods. The impact of prescribing antimicrobial therapy on the duration or severity of symptoms could not be established due to the small sample size, but the results may indicate that antimicrobial treatment is not always necessary.

Participants could turn off reminder messages resulting in incomplete diary entries. However, this feasibility study showed that the collection of patient data through mobile phone apps is feasible and highly effective to collect real-time data on the natural course of the infection, subject to treatment. Participants

should be made aware of the importance of daily entries when downloading the app and this should be part of the education for both the GP and patient.

Conclusion

Due to the response rate associated with the UTI mobile phone app within this feasibility study, it is difficult for the authors to conclusively outline how text messaging or mobile phone apps can help improve patient outcomes. However, this feasibility study does identify the potential for bridging the gap between data collection from patients recruited from multiple research sites in clinical studies and disseminating the results to improve clinical practice. This feasibility study highlights that when a patient begins to engage with a data collection method related to their illness, in this case text messaging or a mobile phone app, they are likely to continue to do so in the end. By collecting patient data in real time through mobile methods, this study highlights the potential of monitoring the symptoms of patients with acute, short-lived illnesses, data that have been difficult to capture in the past due to minimal interaction with the patient after their initial consultation. This knowledge highlights the potential of capturing patient symptom data in real time in the future within the clinical setting, with the possibility of opening up a dialog between patients and GPs.

Retrospective accounts of illnesses are often used in primary care to diagnose illnesses. There are no studies to our knowledge that report real-time versus retrospective reporting of symptom type and severity for UTI. A study comparing real-time reporting of schizophrenic patients used mobile devices to provide real-time data on their symptoms for 7 days. The same patients were then asked to complete a survey. Their results showed that retrospective accounts through surveys captured average ratings only and surveys were unable to capture variability of symptoms over time [15]. This feasibility study showed similar trends; however, more research is needed to investigate this further.

Symptom diaries for lower respiratory tract infections have been shown to be easy to use for measuring symptoms and treatment effects [16]. Diaries have also been used in the past to investigate natural course and treatment options for UTI. In Little et al's study [17], only 64% of participants returned complete symptom diaries. The bias of incomplete data could be avoided with an app that electronically extracts data entries each day. In another study on antimicrobial use in UTI, researchers used follow-up telephone calls three days after initiation of treatment to remind patients to complete their diaries. Patients also received a follow-up call 28 days after their initial consultation to remind them to complete the survey and return a urine sample [18]. These methods are labor intensive and biased due to retrospective recording of symptoms and treatment remains an issue.

Within a recent RCT comparing antimicrobial therapy with symptomatic treatment, a diary was used to measure severity of symptoms and treatment compliance [19]. However, to maximize data collection and quality, they used study nurses to make telephone calls at days 1, 3, 5, and 7 to record symptoms and treatment [20]. Even though it improved data quality, this cost can potentially be saved with the use of the UTI diary app, in which reminders and pop-ups can help patients record their symptoms and treatment.

It has been shown that electronic diaries (palm-held devices) with enhanced compliance features were a more effective method of collecting information in comparison with paper-based diaries for chronic pain [21]. This study showed that compliance with paper-based diaries was poor compared to electronic diaries; patients did not complete their paper-based diaries in a timely fashion (ie, backfilling diaries) introducing bias due to retrospective recall and systematic bias because of the self-selection of completion times. To reduce any retrospective recall bias, diaries should be completed close to the time of the event they are trying to measure (ie, antibiotic consumption) [22].

The ubiquitous use of mobile phones provides opportunities to collect high-quality, real-time data through easy-to-use apps. Paper-based surveys can also be cumbersome and inconvenient to access depending on their design. Apps have been shown to be acceptable for patients and to save time and money in health research.

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Authors' Contributions

SD coordinated the design of both the text message and UTI diary app workflows. SD also drafted the manuscript along with AV who conceived the SIMPle study. MT cleaned and conducted the statistical analysis as part of this paper. All authors were involved in conceptualizing the study and reviewing the manuscript.

Conflicts of Interest

None declared.

References

1. Gaggioli A, Pioggia G, Tartarisco G, Baldus G, Corda D, Cipresso P, et al. A mobile data collection platform for mental health research. Pers Ubiquit Comput 2011 Sep 30;17(2):241-251. [doi: 10.1007/s00779-011-0465-2]
2. Hall A, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. Annu Rev Public Health 2015 Mar 18;36:393-415 [FREE Full text] [doi: 10.1146/annurev-publhealth-031914-122855] [Medline: 25785892]
3. Labrique A, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. Glob Health Sci Pract 2013 Aug;1(2):160-171 [FREE Full text] [doi: 10.9745/GHSP-D-13-00031] [Medline: 25276529]
4. Eurostat Pocketbooks: Key Figures on Europe. 2012 Edition. Luxemberg: Publications Office of the European Union; 2012.
5. Comreg. Irish Communications Market: Quarterly Key Data Report. Dublin, Ireland: Comreg; 2011.
6. Consumer Barometer. 2016. Trending data URL: https://www.consumerbarometer.com/en/trending/?countryCode=IE&category=TRN-NOFILTER-ALL [accessed 2016-02-10]
7. Statista. 2015. Number of mobile app downloads worldwide from 2009 to 2017 URL: https://www.statista.com/statistics/271644/worldwide-free-and-paid-mobile-app-store-downloads/ [accessed 2017-04-04] [WebCite Cache ID 6pTHkkt2U]
8. Dale O, Hagen KB. Despite technical problems personal digital assistants outperform pen and paper when collecting patient diary data. J Clin Epidemiol 2007 Jan;60(1):8-17. [doi: 10.1016/j.jclinepi.2006.04.005] [Medline: 17161749]
9. Oldenburg B, Taylor CB, O'Neil A, Cocker F, Cameron LD. Using new technologies to improve the prevention and management of chronic conditions in populations. Annu Rev Public Health 2015 Mar 18;36:483-505. [doi: 10.1146/annurev-publhealth-031914-122848] [Medline: 25581147]
10. Shen H. Smartphones set to boost large-scale health studies. Nature 2015 Mar 10:1. [doi: 10.1038/nature.2015.17083]
11. Ventola CL. Mobile devices and apps for health care professionals: uses and benefits. P T 2014 May;39(5):356-364 [FREE Full text] [Medline: 24883008]
12. Baerheim A, Digranes A, Jureen R, Malterud K. Generalized symptoms in adult women with acute uncomplicated lower urinary tract infection: an observational study. MedGenMed 2003 Jul 01;5(3):1 [FREE Full text] [Medline: 14600638]
13. Duane S, Callan A, Galvin S, Murphy AW, Domegan C, O'Shea E, et al. Supporting the improvement and management of prescribing for urinary tract infections (SIMPle): protocol for a cluster randomized trial. Trials 2013 Dec 23;14:441 [FREE Full text] [doi: 10.1186/1745-6215-14-441] [Medline: 24359543]
14. Vellinga A, Galvin S, Duane S, Callan A, Bennett K, Cormican M, et al. Intervention to improve the quality of antimicrobial prescribing for urinary tract infection: a cluster randomized trial. Can Med Assoc J 2015. [doi: 10.1503/cmaj.150601]
15. Ben-Zeev D, McHugo GJ, Xie H, Dobbins K, Young MA. Comparing retrospective reports to real-time/real-place mobile assessments in individuals with schizophrenia and a nonclinical comparison group. Schizophr Bull 2012 May;38(3):396-404 [FREE Full text] [doi: 10.1093/schbul/sbr171] [Medline: 22302902]
16. Watson L, Little P, Moore M, Warner G, Williamson I. Validation study of a diary for use in acute lower respiratory tract infection. Fam Pract 2001 Oct;18(5):553-554. [Medline: 11604383]
17. Little P, Merriman R, Turner S, Rumsby K, Warner G, Lowes J, et al. Presentation, pattern, and natural course of severe symptoms, and role of antibiotics and antibiotic resistance among patients presenting with suspected uncomplicated urinary tract infection in primary care: observational study. BMJ 2010 Feb 05;340:b5633 [FREE Full text] [Medline: 20139213]
18. McNulty CA, Richards J, Livermore DM, Little P, Charlett A, Freeman E, et al. Clinical relevance of laboratory-reported antibiotic resistance in acute uncomplicated urinary tract infection in primary care. J Antimicrob Chemother 2006 Nov;58(5):1000-1008. [doi: 10.1093/jac/dkl368] [Medline: 16998209]
19. Vik I, Bollestad M, Grude N, Bærheim A, Mölstad S, Bjerrum L, et al. Ibuprofen versus mecillinam for uncomplicated cystitis--a randomized controlled trial study protocol. BMC Infect Dis 2014 Dec 17;14:693 [FREE Full text] [doi: 10.1186/s12879-014-0693-y] [Medline: 25516016]
20. Gágyor I, Bleidorn J, Kochen M, Schmiemann G, Wegscheider K, Hummers-Pradier E. Ibuprofen versus fosfomycin for uncomplicated urinary tract infection in women: randomised controlled trial. BMJ 2015 Dec 23;351:h6544 [FREE Full text] [Medline: 26698878]
21. Stone AA, Shiffman S, Schwartz JE, Broderick JE, Hufford MR. Patient compliance with paper and electronic diaries. Control Clin Trials 2003 Apr;24(2):182-199. [Medline: 12689739]
22. Shiffman S, Hufford M, Hickcox M, Paty JA, Gnys M, Kassel JD. Remember that? A comparison of real-time versus retrospective recall of smoking lapses. J Consult Clin Psychol 1997 Apr;65(2):292-300. [Medline: 9086693]

Abbreviations

GP: general practitioner
RCT: randomized controlled trial
SIMPle: Supporting the Improvement and Management of UTIs
SMS: short message service
UTI: urinary tract infection

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Protocol

Implementing an Internet-Delivered Skin Cancer Genetic Testing Intervention to Improve Sun Protection Behavior in a Diverse Population: Protocol for a Randomized Controlled Trial

Jennifer L Hay[1*], PhD; Marianne Berwick[2*], PhD; Kate Zielaskowski[1], MS; Kirsten AM White[2], PhD; Vivian M Rodríguez[3], PhD; Erika Robers[2], MA; Dolores D Guest[2], PhD, RD; Andrew Sussman[2], PhD, MCRP; Yvonne Talamantes[2], BS; Matthew R Schwartz[2], BS; Jennie Greb[2], MA; Jessica Bigney[2], MD; Kimberly A Kaphingst[4], ScD; Keith Hunley[2], PhD; David B Buller[5], PhD

[1]Memorial Sloan Kettering Cancer Center, Department of Psychiatry & Behavioral Sciences, New York, NY, United States

[2]University of New Mexico, Albuquerque, NM, United States

[3]Center for Mind+Body Health, Charlottesville, VA, United States

[4]University of Utah, Salt Lake City, UT, United States

[5]Klein Buendel, Inc., Golden, CO, United States

[*]these authors contributed equally

Corresponding Author:
Jennifer L Hay, PhD
Memorial Sloan Kettering Cancer Center
Department of Psychiatry & Behavioral Sciences
641 Lexington Avenue
7th Floor
New York, NY, 10022
United States
Phone: 1 6468880039
Fax: 1 212 888 2584
Email: hayj@mskcc.org

Abstract

Background: Limited translational genomic research currently exists to guide the availability, comprehension, and appropriate use of personalized genomics in diverse general population subgroups. Melanoma skin cancers are preventable, curable, common in the general population, and disproportionately increasing in Hispanics.

Objective: Variants in the *melanocortin-1 receptor* (*MC1R*) gene are present in approximately 50% of the population, are major factors in determining sun sensitivity, and confer a 2-to-3-fold increase in melanoma risk in the general population, even in populations with darker skin. Therefore, feedback regarding *MC1R* risk status may raise risk awareness and protective behavior in the general population.

Methods: We are conducting a randomized controlled trial examining Internet presentation of the risks and benefits of personalized genomic testing for *MC1R* gene variants that are associated with increased melanoma risk. We will enroll a total of 885 participants (462 participants are currently enrolled), who will be randomized 6:1 to personalized genomic testing for melanoma risk versus waiting list control. Control participants will be offered testing after outcome assessments. Participants will be balanced across self-reported Hispanic versus non-Hispanic ethnicity (n=750 in personalized genomic testing for melanoma risk arm; n=135 in control arm), and will be recruited from a general population cohort in Albuquerque, New Mexico, which is subject to year-round sun exposure. Baseline surveys will be completed in-person with study staff and follow-up measures will be completed via telephone.

Results: Aim 1 of the trial will examine the personal utility of personalized genomic testing for melanoma risk in terms of short-term (3-month) sun protection and skin screening behaviors, family and physician communication, and melanoma threat and control beliefs (ie, putative mediators of behavior change). We will also examine potential unintended consequences of testing among those who receive average-risk personalized genomic testing for melanoma risk findings, and examine predictors of sun protection at 3 months as the outcome. These findings will be used to develop messages for groups that receive average-risk

feedback. Aim 2 will compare rates of test consideration in Hispanics versus non-Hispanics, including consideration of testing pros and cons and registration of a decision to either accept or decline testing. Aim 3 will examine personalized genomic testing for melanoma risk feedback comprehension, recall, satisfaction, and cancer-related distress in those who undergo testing, and whether these outcomes differ by ethnicity (Hispanic vs non-Hispanic), or sociocultural or demographic factors. Final outcome data collection is anticipated to be complete by October 2017, at which point data analysis will commence.

Conclusions: This study has important implications for personalized genomics in the context of melanoma risk, and may be broadly applicable as a model for delivery of personalized genomic feedback for other health conditions.

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KEYWORDS

genetic testing; primary care; online health education; melanoma prevention; skin cancer risk; genetic risk communication

Introduction

Melanoma is a rapidly increasing and preventable cancer in the general population. Melanoma incidence rates have increased more rapidly than any other cancer in the past several decades [1,2]. Melanoma accounts for 70% of skin cancer deaths each year [3], and is currently the fourth most common cancer among men and sixth most common among women, both in the Unites States [3] and in New Mexico [4]. Among Hispanics, disproportionate increases in melanoma (particularly thicker tumors with poorer prognoses) have been documented in states with high levels of year-round sun exposure, such as California and Florida [5-9]. For example, in 2010 Rouhani and colleagues [5] compared data from the Florida Cancer Data System (FCDS) with national incidence rates from the Surveillance, Epidemiology, and End Results (SEER) Program. Male Hispanics from the FCDS had a 20% higher incidence rate of melanoma between 1992 and 2004, relative to SEER. Nationally, incidence rates continue to rise among people of lower socioeconomic status and among older men [9-11]. In nonwhites, melanoma results in greater morbidity and mortality due to the disease often being identified at later stages, and because of low physician and patient awareness that melanomas occur in these populations [5,8,12-15]. By 2060, Hispanics will comprise 29% of the US population, further increasing the public health significance of melanoma in Hispanics [16].

Ultraviolet radiation delivered via sunlight is the predominant modifiable cause of melanoma, with approximately 65-90% of melanomas caused by ultraviolet radiation [17-19]. As such, melanoma risk reduction recommendations include daily sun protection, such as sun exposure avoidance, use of hats and clothing, and use of sunscreen [20]. However, most individuals do not use sunscreen, wear protective clothing, or seek shade on a regular basis [21], and in the United States, large general population surveys show that approximately 35% of the population uses sunscreen consistently [20,22,23]. This behavior extends to Hispanics of varying skin types [24,25], and Hispanics in the United States have high sunburn rates [26].

Personalized genomic testing for melanoma risk may promote risk awareness and risk reduction in the general population. Variants of the *melanocortin-1 receptor* gene (*MC1R*) confer moderate melanoma and basal cell cancer risks in the general population [27]. This gene is located on the long arm of chromosome 16 and is related to cutaneous pigmentation (eg, fair skin, red hair) [28-37]. A great deal of accumulated evidence, including systematic analyses of candidate genes, genome wide-association studies, and a recent meta-analysis of 12 melanoma case-control studies involving 6000 individuals [38], has identified nine risk-increasing variants for melanoma with odds ratios ranging from 1.42 (95% CI 1.09-1.85) to 2.45 (95% CI 1.32-4.55) [39].

Importantly, variation in *MC1R* is associated with melanoma risk after adjustment for hair color and skin type [32-34,40-42]. As such, *MC1R* predicts melanoma risk in African-American [43], Spanish [44], and Mediterranean populations [34], with at least one study indicating that *MC1R* may confer greater risk on individuals with darker skin, compared to those with lighter skin [45]. Across Hispanic and non-Hispanic populations, approximately 50% of individuals have at least one risk variant [40,45]. This frequency is consistent across Europe [46]. Hispanics in Albuquerque, New Mexico have substantial Spanish ancestry [47,48], so we expect to find the frequency of at least one risk variant to be 50% across Hispanic and non-Hispanic study participants [44].

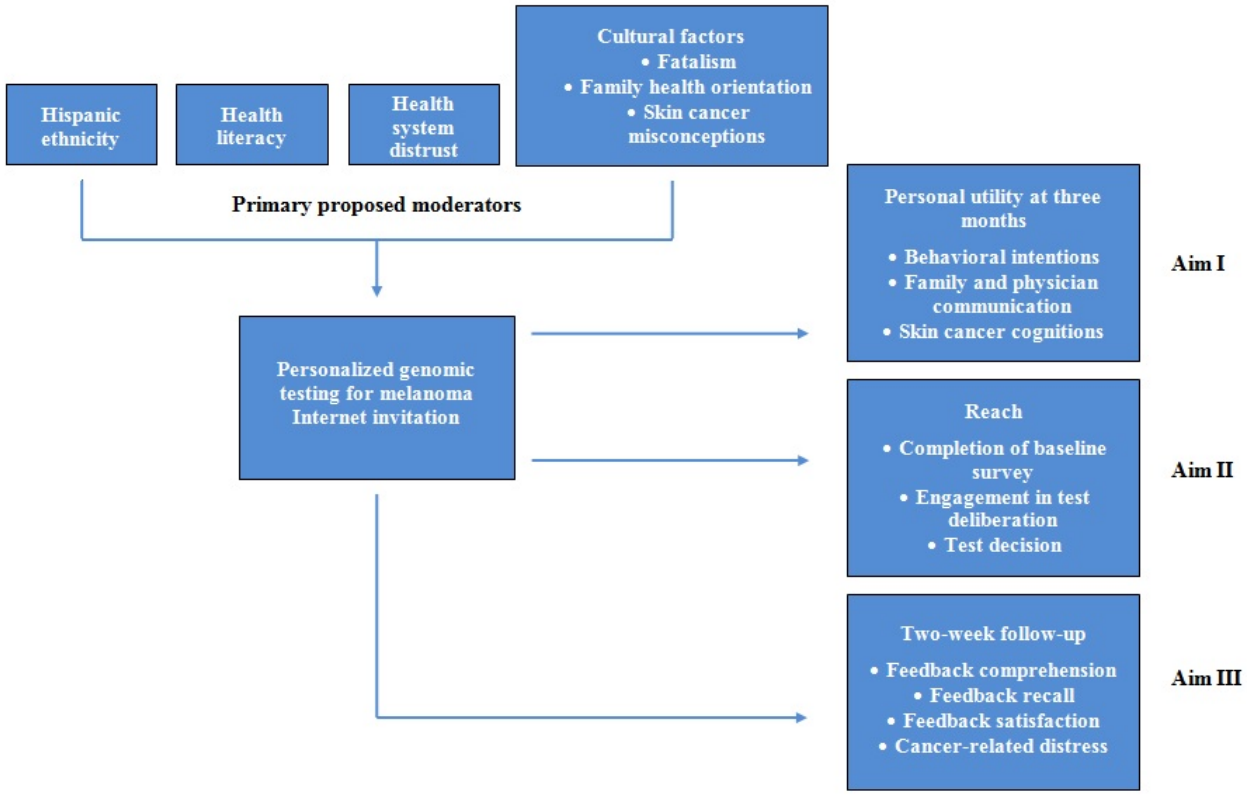
The translation of personalized genomics into real-world general population application is necessary [49] but understudied [50]. The sequencing of the human genome [51] and the isolation of high-risk mutations in tumor suppressor genes has led to the rapid development of clinically useful genetic testing strategies for various uncommon hereditary cancer syndromes. Psychosocial research has highlighted predictors and outcomes of genetic testing in high-risk families who present in specialized clinics and receive extensive genetic counseling [52,53], and is increasingly addressing the needs of diverse, high-risk individuals and families [54,55]. However, since most research has been conducted in the context of familial disease, it is not clear how the general population will respond to personalized genomics. A 2016 report from the National Academy of Sciences has highlighted the pressing need to address access issues in genomic medicine [56]. Despite this need, for-profit companies are already marketing and offering genetic testing directly to consumers [57-60]. This model has largely bypassed behavioral research that could ensure broad utility and reach of this technology through diverse populations, arguing for the time-sensitive need to develop an empirical basis to maximize the benefits and minimize the harms of genomic feedback, even as evidence for specific gene variants and panels inevitably shifts over time [59].

Communication and health behavior theories inform the anticipated impact of personalized genomic testing for melanoma risk. We propose that the personal utility of personalized genomic testing for melanoma risk can be best understood via enhanced communication regarding skin cancer risk with physicians and family, and individual belief processes (ie, arousal of health threat and threat control beliefs). Communication with family and physicians concerning skin cancer risk might be especially important among some individuals, if family opinions are prioritized within a collectivist culture and value system [61]. Protection Motivation Theory [62,63] proposes that individual beliefs, including heightened illness threat (beliefs about severity, susceptibility) and heightened risk information about skin cancer, lead to protective health behaviors when control beliefs are high. Control beliefs involve confidence to perform the behavior (self-efficacy) and confidence in the effectiveness of the behavior (response-efficacy). This study tests the role of personalized genomic testing for melanoma risk in influencing control and illness threat beliefs and communication, which are proposed mediators of behavioral outcomes.

We will examine the reach (defined as consideration of the pros and cons of testing and registration of test decision) of a feasible, generalizable channel with high dissemination potential: the Internet. We will also compare factors (Hispanic ethnicity, health literacy, health system distrust, sociocultural factors) that may differentially impact reach. Over the past decade, the rapid pace of discovery of risk-influencing genes and the use of the Internet as an important source of health information have evolved in parallel. However, the use of the Internet for health information drops sharply and directly with literacy levels, so we will assess health literacy as a moderator of reach in this study [64]. To date, uptake of Internet direct-to-consumer personalized genomic testing has generally been concentrated among white, highly-educated, and health-literate consumers [65]. This disproportionate access is a clear media justice issue, as the continuation of these trends [65-67] could widen health knowledge gaps [68] and the *digital divide* [69,70] in underserved populations, in the context of personalized genomics.

Based on these findings, prior work in primary care populations [71,72], as well as research examining barriers to participation among minority individuals in general cancer prevention trials [73,74], we anticipate that Hispanics may be less easily reached by personalized genomic testing for melanoma risk [75]. However, the Internet gives engaged individuals a direct method of accessing health information on a breadth of topics, and represents one of the most frequent reasons that individuals consult the Internet. A 2012 Pew Research Center Survey found that most general Internet users (66% of Hispanics; 73% of non-Hispanic whites) used the Internet to find health information [76]. A recent study indicated that Hispanics are highly receptive to online cancer information [77]. In the case of personalized genomics, the Internet could provide needed privacy for individuals to consider the benefits and drawbacks of testing. Indeed, for-profit companies have attempted to capitalize on this potential, and this may lead to disproportionate utilization among those who distrust (and may seek to bypass) the health system. Therefore, distrust of the health system, found to be highly relevant in minorities [78,79], may differentially impact reach. Finally, Hispanic sociocultural factors that are known to influence cancer prevention and screening activities [80], including cancer fatalism [81,82], an orientation to health that prioritizes the family over the individual [83], and specific misperceptions about skin cancer that are more common in Hispanics than non-Hispanics [15,84], may help us examine reasons for differential personalized genomic testing for melanoma risk reach. Examining these factors will help explain differences in reach by ethnic group, and thus provide critical direction in future personalized genomic testing for melanoma risk modifications for broad dissemination (see Figure 1).

Figure 1. Conceptual model.



Specific Aims

This randomized controlled trial, "SOMBRA: Skin health Online for Melanoma: Better Risk Assessment" examines Internet presentation of the risks and benefits of personalized genomic testing for melanoma risk versus wait-list controls who are not offered testing. The study will compare personal utility and reach in a general population of English- or Spanish-speaking cohort in Albuquerque, New Mexico, which experiences year-round sun exposure.

In Aim 1, we will examine the personal utility of personalized genomic testing for melanoma risk in terms of short-term (3 months after testing) sun protection and skin screening (ie, behaviors), communication, and melanoma threat and control beliefs (ie, putative mediators of behavior change). Guided by Protection Motivation Theory [62], we hypothesize that behaviors and putative mediators will be higher in those who test, compared to those who decline testing or wait-list controls. Given that an important challenge of personal genomics involves the potential for those who receive *negative* genetic feedback to increase risky behaviors [85], we will also examine this potential unintended consequence of testing. To do so, we will conduct a subgroup analysis among those who receive average-risk personalized genomic testing for melanoma risk findings, and examine sun protection at 3 months as the outcome. Predictors will include baseline melanoma threat and control beliefs, melanoma risk factors, and demographics. These findings may be used in future studies to develop messages for groups that receive average-risk feedback, which accounts for large segments of those tested for moderate risk susceptibility factors across many diseases.

In Aim 2, we will examine differential reach of personalized genomic testing for melanoma risk between Hispanics and non-Hispanics, and potential explanations for any differential reach. Additional assessments of reach include baseline survey completion and the decision to pursue personalized genomic testing for melanoma risk testing. For the reasons listed above, we hypothesize that those who self-identify as Hispanic will show reduced reach, and that this reduction will in fact be the product of differences between Hispanics and non-Hispanics in relation to health literacy, health system distrust, and sociocultural factors [80], including cancer fatalism [81], family health orientation [83], and skin cancer misperceptions [15,84]. These results will inform future personalized genomic testing for melanoma risk modifications for Hispanics.

Finally, in Aim 3, among those who undergo testing we will examine test comprehension, recall and satisfaction, and cancer-related distress two weeks after test receipt. We will also examine whether these outcomes differ by ethnicity (Hispanic vs non-Hispanic) health literacy, health system distrust, sociocultural, or demographic factors.

Methods

Website Development and Usability Testing

Klein Buendel, Inc., a company specializing in health education programs and multimedia products in chronic disease prevention and control, provided the Web-based computer interface for the personalized genomic testing for melanoma risk education modules and testing invitation. Dr. David Buller (a study coinvestigator) is the Klein Buendel Research Director and an

expert in skin cancer communications strategies. The Multiplex Study led by the National Human Genome Research Institute developed an Internet website where participants could opt to undergo genomic testing and risk feedback for common diseases, including the *MC1R* gene for melanoma risk, that was highly comprehensible, accurately interpreted, and did not increase distress in a primary care population [86,87]. We adapted these materials for our current study, and the modules are: (1) *What genetic testing can and cannot tell you*, (2) *Skin cancer and genes*, (3) *Your rights if you take part in genetic research*, and (4) *Your decision to be tested or not*. The website retains each of the four feasible Multiplex Study educational modules, with comprehension questions contained inside a website interface. The interface includes help files, navigation devices, and data collection code. The interface was tested and beta-tested by data professionals at Klein Buendel for stability and accuracy, and is hosted on secure data servers at Klein Buendel. Participants randomized to the personalized genomic testing for melanoma risk study arm view these materials via the Internet. To assess website usability, we conducted semistructured interviews (n=9) with English-speaking (n=8) and Spanish-speaking (n=1) primary care patients at 1209 Clinic, a University of New Mexico (UNM) General Internal Medicine Clinic that represents the primary recruitment site for the study. Any issue raised by at least one participant or study team member was evaluated for revision. Overall, participants found the website usable with 18 problems identified (eg, web pages with too much text, confusing wording, and unclear instructions). The research team developed solutions for these problems, which were confirmed with Klein Buendel before implementation.

Spanish Translation and Cognitive Interviews

We followed published guidance for translation and cognitive interviewing drawn from *Translation, Review and Adjudication, Pretesting, and Documentation* procedures [88,89]. First, the Memorial Sloan Kettering Cancer Center Linguistic and Cultural Competence Team (led by Mr. Javier Gonzalez and Dr. Francesca Gany, coinvestigators) within the Immigrant Health and Cancer Disparities Service provided Spanish translations and certificates of authenticity of all study materials, including: study invitation flyer, baseline survey, personalized genomic testing for melanoma risk Internet educational modules and corresponding knowledge surveys, buccal cell sample provision instructions, risk feedback comprehension assessment, 3-month telephone outcome survey, and consent forms. We internally reviewed the documents and provided fine-tuning.

Next, we conducted semistructured cognitive interviews (n=28) to assess the comprehension and acceptability of translated study materials with our target population (primary care Spanish-speaking Hispanic patients at 1209 Clinic at UNM) stratified across gender and education levels (≥high school, <high school). Bilingual interviewers administered only a portion of the materials to each participant to reduce patient burden and maximize completion with at least two patients viewing every item. If any issues were raised by at least one participant, a research assistant or the investigator panel (multidisciplinary team composed of experts in qualitative data analysis, linguistic translation, health and genetic literacy, and anthropology) evaluated the item for revision and labeled it as a problem [90]. Procedural details and results are reported elsewhere [91]. Most materials were comprehensible and acceptable, but 33 of 246 terms/concepts were not. These items were modified by the multidisciplinary team and retested. During this phase the team adopted the term *skin cancer* rather than *melanoma* in Internet and risk communication materials, due to the greater comprehensibility of this term in the translation and cognitive interviews.

Randomized Controlled Trial

In our ongoing randomized controlled trial, our bilingual Research Study Assistants approach primary care patients in UNM General Internal Medicine clinics with invitation flyers (English and Spanish) and National Cancer Institute skin cancer information for diverse skin types (available in English and Spanish versions; " *Anyone can get skin cancer* "). Patients are eligible for the study if they have been registered in any UNM clinic for at least six months, assigned a primary care physician in the UNM system, are aged ≥18 years, and are fluent in English or Spanish. We originally limited recruitment to the 1209 Clinic, but expanded to other UNM clinics to boost recruitment rates. If patients are eligible and interested in study participation, they complete the Baseline Survey (including an informed consent form) in-clinic via a semiprivate space with a Research Study Assistant who enters their responses on a dedicated study computer (tablet or laptop computer with wireless Internet access). In prior preliminary studies with UNM primary care patients, we found high levels of receptivity to skin cancer genomic information, yet higher skin cancer misconceptions than in the general population, making this an appropriate study context [84].

If patients are eligible but not interested in participating, we assess reasons for study refusal and ask them to complete a one-minute Refuser Survey (skin cancer risk perceptions, interest in genomic technologies, and demographics). Based on the Multiplex Study [86,87], we expect a 30% baseline survey response rate, for a total sample size of 885. After completion of the Baseline Survey, participants receive US $15 for their time and effort, and either a referral to consider personalized genomic testing for melanoma risk through a secure website *or* wait-list control (randomized 1:6; balanced across Hispanic vs non-Hispanic ethnicity; n=135 in control arm, n=750 in personalized genomic testing for melanoma risk arm). Hispanic ethnicity will be recorded by self-report. Trial design and reporting will adhere to The Consolidated Standards for Reporting Trials Statement [92,93]. Patients will choose Spanish or English study materials, and we will record their preference.

After completing the baseline survey in-clinic, all participants randomized to consider personalized genomic testing for melanoma risk are given an introductory letter inviting them to log onto the study website at their earliest convenience (preferably within the next month) to read the four educational modules regarding personalized genomic testing for melanoma risk, and to answer a series of questions regarding comprehension of, and satisfaction with, the content of each module. In section 4, participants register a test decision. Participants are only able to register a test decision if they have already read and completed the questions in the educational

modules. Those who complete these steps receive a US $5 gift card for each educational module completed, for a total of US $15 in gift cards. Registration of a test decision (yes vs no) is our primary assessment of reach in this study. We expect a minimum of 30% of participants who complete the Baseline Survey to register a test decision, and that this will reach 50% in some subgroups, including those with higher literacy, and non-Hispanic subgroups [94]. Additional assessments of reach include completion of the baseline survey and decision to pursue personalized genomic testing for melanoma risk testing (yes vs no). Those who register a decision to proceed with testing will receive deoxyribonucleic acid (DNA) buccal cell test kits which will allow them to provide a saliva sample for genetic testing, postage prepaid envelopes, and instructions for buccal cell collection. Participants can return their kits at any point. Genetic counseling sessions are available at the participants' request. In accordance with The Multiplex Study [72], we anticipate that 50% of those who consider personalized genomic testing for melanoma risk will return a saliva sample for genetic testing. Testing will be conducted on samples that are received by the lab and results will be mailed within one month.

Genomic DNA will be isolated from buccal cells using Oragene (Ottawa, ON, Canada). The Oragene kit generally provides at least 110 micrograms of high quality DNA. Standard polymerase chain reaction will be used to amplify the 951-nucleotide *MC1R* coding region. All amplified products will be sequenced on an ABI Prism 3100 (Applied Biosystems, Foster City, CA) using BigDye Terminators (Applied Biosystems) according to manufacturer's specifications. Sequencing primers are:

5'-TCGTCTTCAGCACTCTCTTC-3'

5'-TTTAAGGCCAAAGCCCTGGT-3'

5'-AACCTGCACTCACCCATGTA-3'

5'-CTGCAGGTGATCACGTCAAT-3'

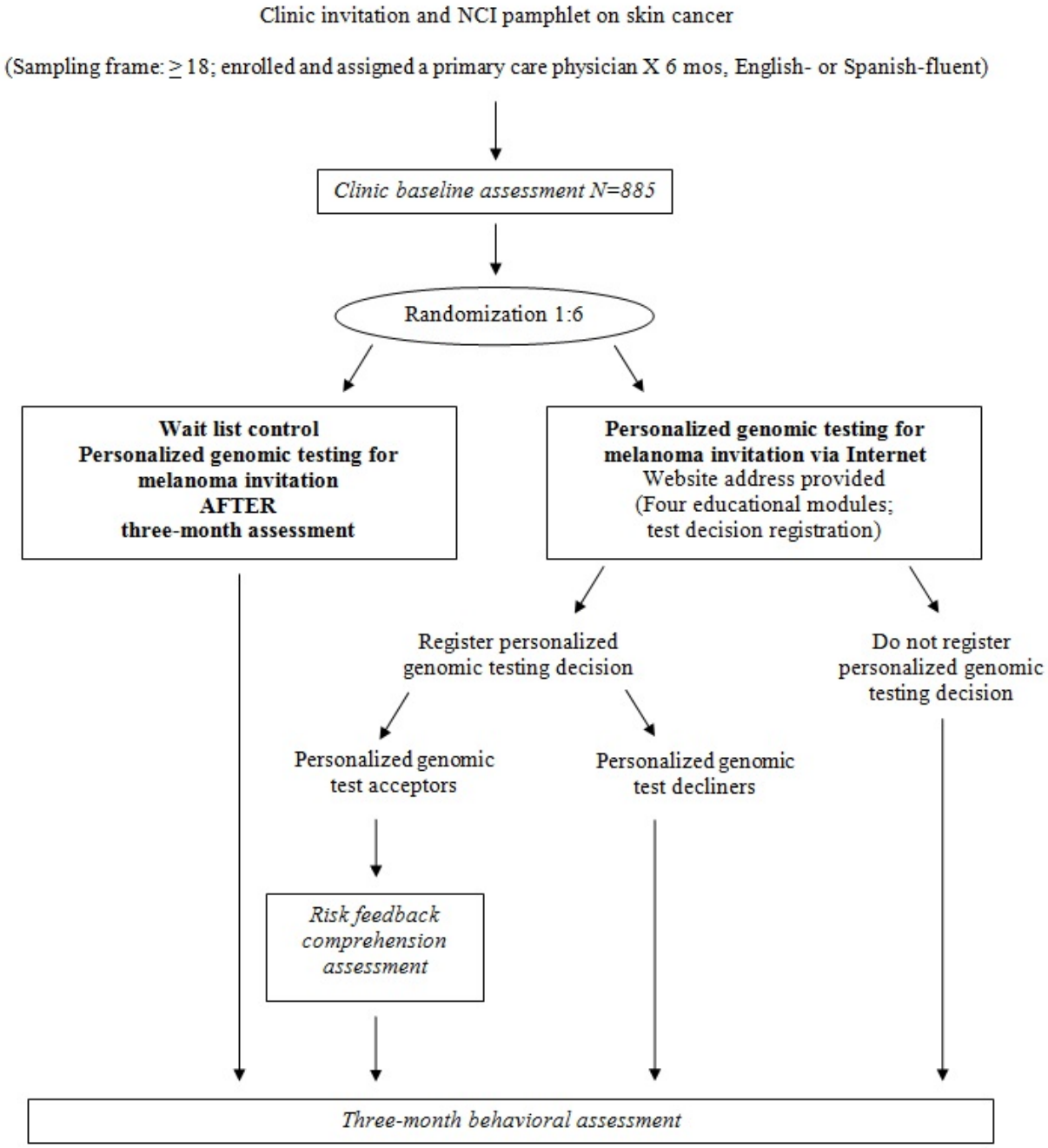
MC1R chromatograms will be read with the aid of Sequencher software version 4.05 (Gene Codes Corp., Ann Arbor, MI) and/or SeqScape software versions 1.0 to 2.1.1 (Applied Biosystems). These data will be read independently by two reviewers. This procedure is standard and has been used in most recent studies examining DNA isolation. We will sequence the coding region of *MC1R* in participants' germline DNA and identify all variants. *MC1R* variants are typically classified as their risk for red hair ("R" variant) and low risk ("r" variant). The *MC1R* variants identified will be characterized as: (1) nonsynonymous or synonymous, (2) coding or noncoding, and (3) *MC1R* variants that are strongly associated with melanoma risk and represented as V60L, D84E, V92M, R142H, R151C, I155T, R160W, R163Q, and D294H; the nine variants that are associated with melanoma, regardless of skin type [41]. Genotype definitions used in these analyses are adapted from work exploring the association between *MC1R* variants and melanoma risk [39]. We estimate that 50% of participants will receive findings concerning at least one *MC1R* risk variant [40,45].

To provide risk feedback, molecular genotypes are combined into two categories: (1) *average-risk feedback*, the presence of no *MC1R* risk alleles associated with risk of melanoma; or (2) *higher risk feedback*, the presence of at least one *MC1R* risk allele, which is associated with risk of developing melanoma (range of 1.47 [95% CI 1.17-1.84] to 2.74 [95% CI 1.53-4.89]). We employ state-of-the-art methods of risk communication used with high comprehension in the Multiplex Study [86,87]. These materials include verbal and picture displays of risk information [95,96], given that people often neglect base rates for a disease and have difficulty understanding joint probabilities and shifting denominators [97]. We will also provide written information to clarify the *bottom line* information, given that individuals tend to rely on the gist of the information [97,98].

All participants who undergo personalized genomic testing for melanoma risk will receive a follow-up call two weeks after results are mailed to them, to assess result comprehension and potential distress (Risk Feedback Comprehension Assessment). All participants who complete this assessment will receive a US $5 gift card. Based on prior literature documenting low levels of distress in individuals undergoing genetic testing for high-risk mutations [99], and those found to carry *Cyclin-Dependent Kinase Inhibitor 2A* mutations indicating high melanoma risk [100], we expect low levels of distress regarding personalized genomic testing for melanoma risk feedback. Those who report high distress will be referred for follow-up by Clinic Director Dr. Jessica Bigney, who addresses distress issues in the UNM clinic.

All participants who complete Baseline Assessments (whether tested or not) are contacted by telephone after 3 months. Participants who complete the follow-up survey receive a US $15 gift card. See Figure 2 for study flow. Measures are outlined in Multimedia Appendix 1.

Figure 2. Study flow. PGT-M: personalized genomic testing for melanoma.



Data Analysis

We will examine four aspects of data quality and distributional assumptions: (1) data skewness, kurtosis, and parametric assumptions; (2) intention-to-treat principles; (3) missing data considerations; and (4) control of potentially inflated type-1 errors due to multiple statistical tests. We assume that up to 20% of the respondents will be unreachable at follow-up; missing assessments may be amenable to imputation by several techniques [101,102].

We will use a series of regression analyses to examine the personal utility of personalized genomic testing for melanoma risk. For these analyses, the dependent variables will be: short-term (3-month) sun protection and skin screening (ie, behaviors); communication; and skin cancer threat and control beliefs (ie, putative mediators of behavior change) [62,63,103]. Given guidelines regarding the importance of consistent use of sunscreen [3], patient-reported sunscreen use frequency will be dichotomized (*frequent* or more vs *sometimes* or less) to indicate consistent versus inconsistent use. Our expected approximate sample size for this analysis will be 708, assuming 20% attrition of our original 885 participants. Personalized genomic testing for melanoma risk uptake status will be categorized into three groups: (1) those who undergo personalized genomic testing for melanoma risk (*acceptors*), (2) those who decline personalized genomic testing for melanoma risk (*decliners*), and (3) those who are not offered personalized genomic testing for melanoma risk (*controls*). A logistic regression model will be used for sun protection outcomes that are dichotomous (eg,

consistent use vs inconsistent use) as a function of personalized genomic testing for melanoma risk uptake. The baseline outcome assessments will be entered as covariates to provide control for ceiling and floor effects. Primary moderators will be considered, including ethnicity (Hispanic vs non-Hispanic), health literacy, health system distrust, sociocultural factors (cancer fatalism, family health orientation, skin cancer misconceptions), and high-risk versus average-risk personalized genomic testing for melanoma risk feedback, as well as demographics and skin cancer risk factors. Average ultraviolet index over the 3-month assessment time period will be considered as a covariate to provide control over seasonal variations in Albuquerque. The hypothesis is supported if there is a significant difference in sunscreen use between personalized genomic testing for melanoma risk acceptors and personalized genomic testing for melanoma risk decliners or controls, such that acceptors show greater sunscreen adherence.

Decreased sun protection may be an unintended consequence of testing among those who receive average-risk personalized genomic testing for melanoma risk feedback [85]. To examine this possibility, we will conduct a subgroup analysis among those who receive average-risk personalized genomic testing for melanoma risk feedback, and examine sun protection outcomes at 3 months as the outcome. Predictors will include baseline skin cancer threat and control beliefs, melanoma risk factors, demographics, and sociocultural factors (health literacy and health system distrust, cancer fatalism, family health orientation, and skin cancer misconceptions). Given the expected sample size for the analysis (n=60; participants who undergo testing and receive average-risk personalized genomic testing for melanoma risk feedback), we will use univariate analyses to guide predictor selection. Nonparametric statistics will be considered when appropriate to guard against violations of parametric assumptions in this restricted sample.

We will examine differential reach of personalized genomic testing for melanoma risk across Hispanics and non-Hispanics, and potential explanations for any differential reach. Reach is defined as registration of a personalized genomic testing for melanoma risk test decision, either accepting or declining testing (dichotomous outcome; test decision or no test decision). Additional assessments of reach include baseline survey completion and decision to pursue personalized genomic testing for melanoma risk testing. Only participants randomized to the personalized genomic testing for melanoma risk arm–those who are offered personalized genomic testing for melanoma risk–will be included in this analysis. Our sample size for this analysis will be 600, assuming 20% attrition of the original 750 who are offered personalized genomic testing for melanoma risk. We aim to offer putative explanations, such as differences in health literacy or skin cancer misconceptions concerning *why* Hispanics offered personalized genomic testing for melanoma risk may be less likely to register a personalized genomic testing for melanoma risk decision. This analysis will involve a moderation framework [104,105], such that reduced reach in Hispanics is moderated by one or more third variables (eg, skin cancer misconceptions). We will use a logistic regression modeling framework to address Aim 2. A standard requirement in moderation analysis [105] entails two sequential statistical findings: (1) there should first be a statistically significant Hispanic effect in Model 1; and (2) after adjusting for the moderator of interest in Model 2, the previously significant main Hispanic effect will no longer be significant. This approach may be applied to a variable coding *Hispanic* (yes vs no) and a moderator variable such as *skin cancer misconceptions*. This analysis will be applied to other putative explanations of why Hispanics might be less likely to register a personalized genomic testing for melanoma risk decision.

Among personalized genomic testing for melanoma risk test acceptors, we will examine (two weeks after test result receipt) test comprehension, recall, satisfaction, and distress. Our sample size for this analysis will be approximately 90, given that we expect to reach 80% (90/114) of those who undergo personalized genomic testing for melanoma risk testing, and thus receive personalized genomic testing for melanoma risk feedback. Based on the Multiplex Study [86,87], we anticipate that personalized genomic testing for melanoma risk feedback will be read by at least 80% of participants who undergo personalized genomic testing, and that at least 80% will correctly recall and accurately interpret their results. We anticipate that most participants (>95%) will report low levels of distress, including nervousness, testing regret, fear, and confusion. We will examine these outcomes using bivariate statistics, and examine differences across ethnicity, health literacy, health system distrust, and sociocultural factors.

Statistical Power

Regarding personal utility in Aim 1, we hypothesize that there will be higher rates of sunscreen use in personalized genomic testing for melanoma risk test acceptors, compared to personalized genomic testing for melanoma risk decliners or controls. We predict that those who accept personalized genomic testing for melanoma risk will have higher levels of sunscreen use (65% regular sunscreen use, consistent with rates of sunscreen use in those with melanoma risk factors [106]), compared to 35% sunscreen use in decliners or controls (consistent with rates of sunscreen use in the general population [20,22,23]). We estimated the statistical power in personal utility between personalized genomic testing for melanoma risk accepters compared to decliners or controls. The comparison between a 65% versus 35% difference in sunscreen use was carried out using Cohen's method [107]. An estimated 65% versus 35% contrast translates to an arcsine-transformed effect size index of 0.61 [107], which yields a statistical power of 99.7% in a hypothesis test of these two proportions between personalized genomic testing for melanoma risk acceptors (an estimated n=90 after 20% attrition) and decliners (n=509 after 20% attrition), at a two-sided test with a tail probability of 0.01 (lower than the conventional 0.05 tail probability to reserve power for subset analyses).

Regarding the outcome of reach in Aim 2, we hypothesize that Hispanics will show reduced reach, but that differences in health literacy, health system distrust, and sociocultural factors (cancer fatalism, family health orientation, skin cancer misconceptions) will explain these findings. This method involves testing a moderation relationship in a logistic regression model. To estimate the statistical power, we ran 400 simulated logistic

regression models, assuming Hispanics at 50% of the sample, and that within the Hispanic group high skin cancer misconceptions would be associated with a 0.38 odds ratio in personalized genomic testing for melanoma risk test registration; high skin cancer misconceptions would be associated with lower personalized genomic testing for melanoma risk registration. When converted to Cohen d, this 0.38 odds ratio translates to an effect size of -0.54, which Cohen considers a *medium* effect size. Based on the Multiplex Study [86], we estimate a minimum of 30% of participants will register a personalized genomic testing for melanoma risk decision among Hispanics, and a higher reach of 50% among non-Hispanics. This 30% versus 50% difference translates to a Cohen effect size of 0.50 [107]. We estimate 81% statistical power to detect a medium effect size at a conventional two-sided type-1 error rate of 5% for a moderator analysis.

In sum, we have adequate power for personal utility and reach to (1) ensure adequate representation of individuals with low health literacy, (2) ensure robust protection against missing data, and (3) ensure sufficient statistical power to detect moderation. If the effect size is larger than estimated, such as a 30% versus 80% difference and a Cohen effect size of 0.65, then we would have power to spare for additional comparisons.

Results

To date, 462 participants have been recruited to the study (203/462, 43.9% Hispanic; 222/462, 48.1% non-Hispanic white; 356/462, 77.1% female; mean age=54) and randomized 1:6 to usual care or the personalized genomic testing for melanoma risk offer. Final outcome data collection is anticipated to be complete by October 2017, at which point data analyses will commence.

Discussion

This study is one of the first population-based efforts to widen the reach of personal genomics in *real-world* settings. Along with other work examining ways to maximize the use of the Internet to bring emerging technologies [108] (including genomics [109]) to the general population, our research will use genomic information to raise melanoma risk awareness and prevention and control behaviors for this rapidly increasing cancer, which is extremely hard to treat when diagnosed beyond stage 1. We use a rigorous randomized controlled trial design, which increases the rigor of the proposal by comparing those who undergo personalized genomic testing for melanoma risk testing to: (1) those who have declined, and (2) those who have not been offered personalized genomic testing for melanoma risk testing. We use an established and feasible approach to Web-based communication regarding skin cancer genetic testing, and measure utility and reach using a real-world approach by which the general population may realistically access it (Internet personalized genomic testing for melanoma risk invitation). We have identified a highly diverse population for assessment in a geographical location that is exposed to year-round sun exposure.

The current proposal will examine potential unintended consequences of *actual* genetic testing, by directly examining those who receive personalized genomic testing for melanoma average-risk results to identify predictors of behavior change in this group. Examination of this question will have important implications for personalized genomics in the context of melanoma risk, and will be broadly applicable as a model for delivery of personalized genomic feedback for other health conditions.

Study limitations include the fact that we do not assess participants for Internet literacy, and do not include detailed assessments regarding context of sun exposure (occupational, recreational). Finally, we did not employ blinding of study condition among study staff.

Conclusions

Our findings will have important implications for personalized genomics in the context of melanoma risk, and will be broadly applicable as a model for delivery of personalized genomic feedback for other conditions in this population. We plan future work to expand personalized genomic testing for melanoma risk to include other melanoma risk and protective markers, and to expand risk stratification to multiple levels as the literature on genetic factors in skin cancer unfolds.

Acknowledgments

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Conflicts of Interest

Dr. David Buller is the Research Director of Klein Buendel.

Multimedia Appendix 1

Study measures.

[PDF File (Adobe PDF File), 13KB - resprot_v6i4e52_app1.pdf]

Multimedia Appendix 2

Peer-review reports from National Cancer Institute grant.

[PDF File (Adobe PDF File), 128KB - resprot_v6i4e52_app2.pdf]

Multimedia Appendix 3

CONSORT publication form.

[PDF File (Adobe PDF File), 644KB - resprot_v6i4e52_app3.pdf]

References

1. Jemal A, Devesa SS, Hartge P, Tucker MA. Recent trends in cutaneous melanoma incidence among whites in the United States. J Natl Cancer Inst 2001 May 02;93(9):678-683. [Medline: 11333289]
2. Ries LA, Melbert D, Krapcho M, Mariotto A, Miller BA, Feuer EJ, et al. SEER Cancer Statistics Review, 1975-2004. Bethesda, MD: National Cancer Institute; 2007. URL: http://seer.cancer.gov/csr/1975_2004/ [accessed 2017-01-30] [WebCite Cache ID 6nuP4OC7H]
3. American Cancer Society. Cancer Facts & Figures. Atlanta, GA: American Cancer Society; 2017. URL: https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2017/cancer-facts-and-figures-2017.pdf [accessed 2017-02-07] [WebCite Cache ID 6o6Y7EwN8]
4. New Mexico Tumor Registry. Top 10 Cancers in New Mexico, 2008-2012. 2017. URL: http://nmtrweb.unm.edu/statistics/top10_20jan2015.pdf [accessed 2017-02-07] [WebCite Cache ID 6o6Ymyw8M]
5. Rouhani P, Pinheiro PS, Sherman R, Arheart K, Fleming LE, Mackinnon J, et al. Increasing rates of melanoma among nonwhites in Florida compared with the United States. Arch Dermatol 2010 Jul;146(7):741-746. [doi: 10.1001/archdermatol.2010.133] [Medline: 20644034]
6. Cockburn MG, Zadnick J, Deapen D. Developing epidemic of melanoma in the Hispanic population of California. Cancer 2006 Mar 01;106(5):1162-1168 [FREE Full text] [doi: 10.1002/cncr.21654] [Medline: 16429450]
7. Hu S, Parmet Y, Allen G, Parker DF, Ma F, Rouhani P, et al. Disparity in melanoma: a trend analysis of melanoma incidence and stage at diagnosis among whites, Hispanics, and blacks in Florida. Arch Dermatol 2009 Dec;145(12):1369-1374. [doi: 10.1001/archdermatol.2009.302] [Medline: 20026844]
8. Hu S, Soza-Vento RM, Parker DF, Kirsner RS. Comparison of stage at diagnosis of melanoma among Hispanic, black, and white patients in Miami-Dade County, Florida. Arch Dermatol 2006 Jun;142(6):704-708. [doi: 10.1001/archderm.142.6.704] [Medline: 16785372]
9. Pollitt RA, Clarke CA, Swetter SM, Peng DH, Zadnick J, Cockburn M. The expanding melanoma burden in California hispanics: importance of socioeconomic distribution, histologic subtype, and anatomic location. Cancer 2011 Jan 01;117(1):152-161 [FREE Full text] [doi: 10.1002/cncr.25355] [Medline: 20737564]
10. Linos E, Swetter SM, Cockburn MG, Colditz GA, Clarke CA. Increasing burden of melanoma in the United States. J Invest Dermatol 2009 Jul;129(7):1666-1674 [FREE Full text] [doi: 10.1038/jid.2008.423] [Medline: 19131946]
11. Zell JA, Cinar P, Mobasher M, Ziogas A, Meyskens FL, Anton-Culver H. Survival for patients with invasive cutaneous melanoma among ethnic groups: the effects of socioeconomic status and treatment. J Clin Oncol 2008 Jan 01;26(1):66-75. [doi: 10.1200/JCO.2007.12.3604] [Medline: 18165642]
12. Byrd-Miles K, Toombs EL, Peck GL. Skin cancer in individuals of African, Asian, Latin-American, and American-Indian descent: differences in incidence, clinical presentation, and survival compared to Caucasians. J Drugs Dermatol 2007 Jan;6(1):10-16. [Medline: 17373156]
13. Pichon LC, Corral I, Landrine H, Mayer JA, Adams-Simms D. Perceived skin cancer risk and sunscreen use among African American adults. J Health Psychol 2010 Nov;15(8):1181-1189. [doi: 10.1177/1359105310364177] [Medline: 20522507]
14. Robinson JK, Joshi KM, Ortiz S, Kundu RV. Melanoma knowledge, perception, and awareness in ethnic minorities in Chicago: recommendations regarding education. Psychooncology 2011 Mar;20(3):313-320. [doi: 10.1002/pon.1736] [Medline: 20878831]
15. Roman C, Lugo-Somolinos A, Thomas N. Skin cancer knowledge and skin self-examinations in the Hispanic population of North Carolina: the patient's perspective. JAMA Dermatol 2013 Jan;149(1):103-104. [doi: 10.1001/2013.jamadermatol.263] [Medline: 23324772]
16. Colby S, Ortman J. Population Estimates and Projections.: United States Census Bureau; 2015. Projection of the size and composition of the U.S. population: 2014 to 2060 URL: https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf [accessed 2017-03-10] [WebCite Cache ID 6oreQyVec]
17. Armstrong BK, Kricker A. How much melanoma is caused by sun exposure? Melanoma Res 1993 Dec;3(6):395-401. [Medline: 8161879]
18. Dal H, Boldemann C, Lindelöf B. Does relative melanoma distribution by body site 1960-2004 reflect changes in intermittent exposure and intentional tanning in the Swedish population? Eur J Dermatol 2007;17(5):428-434. [doi: 10.1684/ejd.2007.0242] [Medline: 17673388]

19. Whiteman DC, Whiteman CA, Green AC. Childhood sun exposure as a risk factor for melanoma: a systematic review of epidemiologic studies. Cancer Causes Control 2001 Jan;12(1):69-82. [Medline: 11227927]
20. Centers for Disease Control and Prevention (CDC). Sunburn prevalence among adults--United States, 1999, 2003, and 2004. MMWR Morb Mortal Wkly Rep 2007 Jun 01;56(21):524-528 [FREE Full text] [Medline: 17538527]
21. Kasparian NA, McLoone JK, Meiser B. Skin cancer-related prevention and screening behaviors: a review of the literature. J Behav Med 2009 Oct;32(5):406-428. [doi: 10.1007/s10865-009-9219-2] [Medline: 19521760]
22. Coups EJ, Manne SL, Heckman CJ. Multiple skin cancer risk behaviors in the U.S. population. Am J Prev Med 2008 Feb;34(2):87-93. [doi: 10.1016/j.amepre.2007.09.032] [Medline: 18201637]
23. Hay J, Coups EJ, Ford J, DiBonaventura M. Exposure to mass media health information, skin cancer beliefs, and sun protection behaviors in a United States probability sample. J Am Acad Dermatol 2009 Nov;61(5):783-792 [FREE Full text] [doi: 10.1016/j.jaad.2009.04.023] [Medline: 19596487]
24. Coups EJ, Stapleton JL, Hudson SV, Medina-Forrester A, Goydos JS, Natale-Pereira A. Skin cancer screening among Hispanic adults in the United States: results from the 2010 National Health Interview Survey. Arch Dermatol 2012 Jul;148(7):861-863 [FREE Full text] [doi: 10.1001/archdermatol.2012.615] [Medline: 22801634]
25. Coups EJ, Stapleton JL, Hudson SV, Medina-Forrester A, Natale-Pereira A, Goydos JS. Sun protection and exposure behaviors among Hispanic adults in the United States: differences according to acculturation and among Hispanic subgroups. BMC Public Health 2012 Nov 15;12:985 [FREE Full text] [doi: 10.1186/1471-2458-12-985] [Medline: 23153104]
26. Saraiya M, Hall HI, Uhler RJ. Sunburn prevalence among adults in the United States, 1999. Am J Prev Med 2002 Aug;23(2):91-97. [Medline: 12121796]
27. Udayakumar D, Tsao H. Moderate- to low-risk variant alleles of cutaneous malignancies and nevi: lessons from genome-wide association studies. Genome Med 2009 Oct 27;1(10):95 [FREE Full text] [doi: 10.1186/gm95] [Medline: 19863770]
28. Chaudru V, Laud K, Avril M, Minière A, Chompret A, Bressac-de PB, et al. Melanocortin-1 receptor (MC1R) gene variants and dysplastic nevi modify penetrance of CDKN2A mutations in French melanoma-prone pedigrees. Cancer Epidemiol Biomarkers Prev 2005 Oct;14(10):2384-2390 [FREE Full text] [doi: 10.1158/1055-9965.EPI-04-0777] [Medline: 16214921]
29. Duffy DL, Box NF, Chen W, Palmer JS, Montgomery GW, James MR, et al. Interactive effects of MC1R and OCA2 on melanoma risk phenotypes. Hum Mol Genet 2004 Feb 15;13(4):447-461. [doi: 10.1093/hmg/ddh043] [Medline: 14709592]
30. Flanagan N, Healy E, Ray A, Philips S, Todd C, Jackson IJ, et al. Pleiotropic effects of the melanocortin 1 receptor (MC1R) gene on human pigmentation. Hum Mol Genet 2000 Oct 12;9(17):2531-2537. [Medline: 11030758]
31. Goldstein AM, Landi MT, Tsang S, Fraser MC, Munroe DJ, Tucker MA. Association of MC1R variants and risk of melanoma in melanoma-prone families with CDKN2A mutations. Cancer Epidemiol Biomarkers Prev 2005 Sep;14(9):2208-2212 [FREE Full text] [doi: 10.1158/1055-9965.EPI-05-0321] [Medline: 16172233]
32. Kanetsky PA, Ge F, Najarian D, Swoyer J, Panossian S, Schuchter L, et al. Assessment of polymorphic variants in the melanocortin-1 receptor gene with cutaneous pigmentation using an evolutionary approach. Cancer Epidemiol Biomarkers Prev 2004 May;13(5):808-819 [FREE Full text] [Medline: 15159314]
33. Kennedy C, ter Huurne J, Berkhout M, Gruis N, Bastiaens M, Bergman W, et al. Melanocortin 1 receptor (MC1R) gene variants are associated with an increased risk for cutaneous melanoma which is largely independent of skin type and hair color. J Invest Dermatol 2001 Aug;117(2):294-300 [FREE Full text] [doi: 10.1046/j.0022-202x.2001.01421.x] [Medline: 11511307]
34. Landi MT, Kanetsky PA, Tsang S, Gold B, Munroe D, Rebbeck T, et al. MC1R, ASIP, and DNA repair in sporadic and familial melanoma in a Mediterranean population. J Natl Cancer Inst 2005 Jul 06;97(13):998-1007. [doi: 10.1093/jnci/dji176] [Medline: 15998953]
35. Matichard E, Verpillat P, Meziani R, Gérard B, Descamps V, Legroux E, et al. Melanocortin 1 receptor (MC1R) gene variants may increase the risk of melanoma in France independently of clinical risk factors and UV exposure. J Med Genet 2004 Feb;41(2):e13 [FREE Full text] [Medline: 14757863]
36. Sturm RA. Skin colour and skin cancer - MC1R, the genetic link. Melanoma Res 2002 Oct;12(5):405-416. [Medline: 12394181]
37. Valverde P, Healy E, Sikkink S, Haldane F, Thody AJ, Carothers A, et al. The Asp84Glu variant of the melanocortin 1 receptor (MC1R) is associated with melanoma. Hum Mol Genet 1996 Oct;5(10):1663-1666. [Medline: 8894704]
38. Raimondi S, Sera F, Gandini S, Iodice S, Caini S, Maisonneuve P, et al. MC1R variants, melanoma and red hair color phenotype: a meta-analysis. Int J Cancer 2008 Jun 15;122(12):2753-2760 [FREE Full text] [doi: 10.1002/ijc.23396] [Medline: 18366057]
39. Pasquali E, García-Borrón JC, Fargnoli MC, Gandini S, Maisonneuve P, Bagnardi V, M-SKIP Study Group. MC1R variants increased the risk of sporadic cutaneous melanoma in darker-pigmented Caucasians: a pooled-analysis from the M-SKIP project. Int J Cancer 2015 Feb 01;136(3):618-631 [FREE Full text] [doi: 10.1002/ijc.29018] [Medline: 24917043]
40. Kanetsky PA, Panossian S, Elder DE, Guerry D, Ming ME, Schuchter L, et al. Does MC1R genotype convey information about melanoma risk beyond risk phenotypes? Cancer 2010 May 15;116(10):2416-2428 [FREE Full text] [doi: 10.1002/cncr.24994] [Medline: 20301115]

41. Kanetsky PA, Rebbeck TR, Hummer AJ, Panossian S, Armstrong BK, Kricker A, et al. Population-based study of natural variation in the melanocortin-1 receptor gene and melanoma. Cancer Res 2006 Sep 15;66(18):9330-9337 [FREE Full text] [doi: 10.1158/0008-5472.CAN-06-1634] [Medline: 16982779]
42. Palmer JS, Duffy DL, Box NF, Aitken JF, O'Gorman LE, Green AC, et al. Melanocortin-1 receptor polymorphisms and risk of melanoma: is the association explained solely by pigmentation phenotype? Am J Hum Genet 2000 Jan;66(1):176-186 [FREE Full text] [doi: 10.1086/302711] [Medline: 10631149]
43. John PR, Makova K, Li W, Jenkins T, Ramsay M. DNA polymorphism and selection at the melanocortin-1 receptor gene in normally pigmented southern African individuals. Ann N Y Acad Sci 2003 Jun;994:299-306. [Medline: 12851329]
44. Scherer D, Nagore E, Bermejo JL, Figl A, Botella-Estrada R, Thirumaran RK, et al. Melanocortin receptor 1 variants and melanoma risk: a study of 2 European populations. Int J Cancer 2009 Oct 15;125(8):1868-1875 [FREE Full text] [doi: 10.1002/ijc.24548] [Medline: 19585506]
45. Demenais F, Mohamdi H, Chaudru V, Goldstein AM, Newton Bishop JA, Bishop DT, et al. Association of MC1R variants and host phenotypes with melanoma risk in CDKN2A mutation carriers: a GenoMEL study. J Natl Cancer Inst 2010 Oct 20;102(20):1568-1583 [FREE Full text] [doi: 10.1093/jnci/djq363] [Medline: 20876876]
46. de Torre C, Garcia-Casado Z, Martínez-Escribano JA, Botella-Estrada R, Bañuls J, Oliver V, et al. Influence of loss of function MC1R variants in genetic susceptibility of familial melanoma in Spain. Melanoma Res 2010 Aug;20(4):342-348. [doi: 10.1097/CMR.0b013e32833b159d] [Medline: 20539244]
47. Bonilla C, Parra EJ, Pfaff CL, Dios S, Marshall JA, Hamman RF, et al. Admixture in the Hispanics of the San Luis Valley, Colorado, and its implications for complex trait gene mapping. Ann Hum Genet 2004 Mar;68(Pt 2):139-153. [Medline: 15008793]
48. Klimentidis YC, Miller GF, Shriver MD. Genetic admixture, self-reported ethnicity, self-estimated admixture, and skin pigmentation among Hispanics and Native Americans. Am J Phys Anthropol 2009 Apr;138(4):375-383. [doi: 10.1002/ajpa.20945] [Medline: 18951390]
49. Green ED, Guyer MS, National Human Genome Research Institute. Charting a course for genomic medicine from base pairs to bedside. Nature 2011 Feb 10;470(7333):204-213. [doi: 10.1038/nature09764] [Medline: 21307933]
50. Khoury MJ, Clauser SB, Freedman AN, Gillanders EM, Glasgow RE, Klein WM, et al. Population sciences, translational research, and the opportunities and challenges for genomics to reduce the burden of cancer in the 21st century. Cancer Epidemiol Biomarkers Prev 2011 Oct;20(10):2105-2114 [FREE Full text] [doi: 10.1158/1055-9965.EPI-11-0481] [Medline: 21795499]
51. Lander ES, Linton LM, Birren B, Nusbaum C, Zody MC, Baldwin J, International Human Genome Sequencing Consortium. Initial sequencing and analysis of the human genome. Nature 2001 Feb 15;409(6822):860-921. [doi: 10.1038/35057062] [Medline: 11237011]
52. Lerman C, Trock B, Rimer BK, Jepson C, Brody D, Boyce A. Psychological side effects of breast cancer screening. Health Psychol 1991;10(4):259-267. [Medline: 1915212]
53. Patenaude AF, Guttmacher AE, Collins FS. Genetic testing and psychology. New roles, new responsibilities. Am Psychol 2002 Apr;57(4):271-282. [Medline: 11975377]
54. Kinney AY, Gammon A, Coxworth J, Simonsen SE, Arce-Laretta M. Exploring attitudes, beliefs, and communication preferences of Latino community members regarding BRCA1/2 mutation testing and preventive strategies. Genet Med 2010 Feb;12(2):105-115 [FREE Full text] [doi: 10.1097/GIM.0b013e3181c9af2d] [Medline: 20061960]
55. Gammon AD, Rothwell E, Simmons R, Lowery JT, Ballinger L, Hill DA, et al. Awareness and preferences regarding BRCA1/2 genetic counseling and testing among Latinas and non-Latina white women at increased risk for hereditary breast and ovarian cancer. J Genet Couns 2011 Dec;20(6):625-638. [doi: 10.1007/s10897-011-9376-7] [Medline: 21691939]
56. Addie S, Olson S, Beachy SH, Rapporteurs, Roundtable on Translating Genomic-Based Research for Health, Board on Health Sciences Policy, Health and Medicine Division, National Academics of Sciences, Engineering, and Medicine. Applying an Implementation Science Approach to Genomic Medicine: Workshop Summary. Washington DC: National Academies Press; 2016:978.
57. Geransar R, Einsiedel E. Evaluating online direct-to-consumer marketing of genetic tests: informed choices or buyers beware? Genet Test 2008 Mar;12(1):13-23. [doi: 10.1089/gte.2007.0024] [Medline: 18373401]
58. Gollust SE, Wilfond BS, Hull SC. Direct-to-consumer sales of genetic services on the Internet. Genet Med 2003;5(4):332-337 [FREE Full text] [doi: 10.1097/01.GIM.0000076972.83711.48] [Medline: 12865763]
59. Khoury MJ, McBride CM, Schully SD, Ioannidis JP, Feero WG, Janssens AC, Centers for Disease Control and Prevention. The Scientific Foundation for personal genomics: recommendations from a National Institutes of Health-Centers for Disease Control and Prevention multidisciplinary workshop. Genet Med 2009 Aug;11(8):559-567 [FREE Full text] [doi: 10.1097/GIM.0b013e3181b13a6c] [Medline: 19617843]
60. Williams-Jones B. Where there's a web, there's a way: commercial genetic testing and the Internet. Community Genet 2003;6(1):46-57. [doi: 10.1159/000069538] [Medline: 12748438]
61. Hallenbeck J. High context illness and dying in a low context medical world. Am J Hosp Palliat Care 2006;23(2):113-118. [doi: 10.1177/104990910602300208] [Medline: 16572749]

62. Robberson M, Rogers R. Beyond fear appeals: negative and positive persuasive appeals to health and self-esteem. J Appl Social Pyschol 1988 Mar;18(3):277-287. [doi: 10.1111/j.1559-1816.1988.tb00017.x]
63. Rogers RW. Cognitive and physiological processes in attitude change: a revised theory of protection motivation. In: Cacioppo JT, Petty RE, editors. Social Psychophysiology: A Sourcebook. New York: Guilford Press; 1983:153-176.
64. Kutner M, Greenberg E, Jin Y, Paulsen C. National Center of Education Statistics. Washington, DC; 2006 Oct. The health literacy of America's adults: results from the 2003 National Assessment of Adult Literacy URL: http://files.eric.ed.gov/fulltext/ED493284.pdf [accessed 2017-03-07] [WebCite Cache ID 6on2vgaX9]
65. Bloss CS, Ornowski L, Silver E, Cargill M, Vanier V, Schork NJ, et al. Consumer perceptions of direct-to-consumer personalized genomic risk assessments. Genet Med 2010 Sep;12(9):556-566. [doi: 10.1097/GIM.0b013e3181eb51c6] [Medline: 20717041]
66. Pagán JA, Su D, Li L, Armstrong K, Asch DA. Racial and ethnic disparities in awareness of genetic testing for cancer risk. Am J Prev Med 2009 Dec;37(6):524-530. [doi: 10.1016/j.amepre.2009.07.021] [Medline: 19944919]
67. Suther S, Kiros G. Barriers to the use of genetic testing: a study of racial and ethnic disparities. Genet Med 2009 Sep;11(9):655-662. [doi: 10.1097/GIM.0b013e3181ab22aa] [Medline: 19752639]
68. Viswanath K, Nagler RH, Bigman-Galimore CA, McCauley MP, Jung M, Ramanadhan S. The communications revolution and health inequalities in the 21st century: implications for cancer control. Cancer Epidemiol Biomarkers Prev 2012 Oct;21(10):1701-1708 [FREE Full text] [doi: 10.1158/1055-9965.EPI-12-0852] [Medline: 23045545]
69. Lorence D, Park H. Group disparities and health information: a study of online access for the underserved. Health Informatics J 2008 Mar;14(1):29-38. [doi: 10.1177/1460458207086332] [Medline: 18258673]
70. Lorence DP, Park H, Fox S. Racial disparities in health information access: resilience of the Digital Divide. J Med Syst 2006 Aug;30(4):241-249. [Medline: 16978003]
71. Hall MJ, Manne SL, Myers RE, Keenan EM, Balshem AM, Weinberg DS. Predictors of patient uptake of colorectal cancer gene environment risk assessment. Genome Med 2012;4(11):92 [FREE Full text] [doi: 10.1186/gm393] [Medline: 23194586]
72. McBride CM, Alford SH, Reid RJ, Larson EB, Baxevanis AD, Brody LC. Characteristics of users of online personalized genomic risk assessments: implications for physician-patient interactions. Genet Med 2009 Aug;11(8):582-587 [FREE Full text] [doi: 10.1097/GIM.0b013e3181b22c3a] [Medline: 19606049]
73. Grann VR, Jacobson JS, Troxel AB, Hershman D, Karp J, Myers C, et al. Barriers to minority participation in breast carcinoma prevention trials. Cancer 2005 Jul 15;104(2):374-379 [FREE Full text] [doi: 10.1002/cncr.21164] [Medline: 15937913]
74. Maxwell AE, Bastani R, Vida P, Warda US. Strategies to recruit and retain older Filipino-American immigrants for a cancer screening study. J Community Health 2005 Jun;30(3):167-179 [FREE Full text] [Medline: 15847243]
75. James RD, Yu J, Henrikson NB, Bowen DJ, Fullerton SM, Health Disparities Working Group. Strategies and stakeholders: minority recruitment in cancer genetics research. Community Genet 2008;11(4):241-249. [doi: 10.1159/000116878] [Medline: 18417972]
76. Fox S, Duggan M. Pew Research Center Internet, Science & Tech. Washington, DC: Pew Research Center's Internet & American Life Project; 2013. Health Online 2013 URL: http://pewinternet.org/Reports/2013/Health-online/Summary-of-Findings.aspx, [accessed 2017-01-30] [WebCite Cache ID 6nuQ1zXNw]
77. Selsky C, Luta G, Noone A, Huerta EE, Mandelblatt JS. Internet access and online cancer information seeking among Latino immigrants from safety net clinics. J Health Commun 2013;18(1):58-70 [FREE Full text] [doi: 10.1080/10810730.2012.688248] [Medline: 23066874]
78. Armstrong K, Putt M, Halbert CH, Grande D, Schwartz JS, Liao K, et al. The influence of health care policies and health care system distrust on willingness to undergo genetic testing. Med Care 2012 May;50(5):381-387 [FREE Full text] [doi: 10.1097/MLR.0b013e31824d748b] [Medline: 22473221]
79. Bernhardt JM, Lariscy RA, Parrott RL, Silk KJ, Felter EM. Perceived barriers to Internet-based health communication on human genetics. J Health Commun 2002;7(4):325-340. [doi: 10.1080/10810730290088166] [Medline: 12356290]
80. Marin G, Sabogal F, Marin B, Otero-Sabogal R, Perez-Stable E. Development of a short acculturation scale for Hispanics. Hisp J Behav Sci 1987 Jun;9(2):183-205. [doi: 10.1177/07399863870092005]
81. Espinosa de Los Monteros K, Gallo LC. The relevance of fatalism in the study of Latinas' cancer screening behavior: a systematic review of the literature. Int J Behav Med 2011 Dec;18(4):310-318 [FREE Full text] [doi: 10.1007/s12529-010-9119-4] [Medline: 20953916]
82. Magai C, Consedine N, Conway F, Neugut A, Culver C. Diversity matters: unique populations of women and breast cancer screening. Cancer 2004 Jun 01;100(11):2300-2307 [FREE Full text] [doi: 10.1002/cncr.20278] [Medline: 15160332]
83. Pasick RJ, Barker JC, Otero-Sabogal R, Burke NJ, Joseph G, Guerra C. Intention, subjective norms, and cancer screening in the context of relational culture. Health Educ Behav 2009 Oct;36(5 Suppl):91S-110S [FREE Full text] [doi: 10.1177/1090198109338919] [Medline: 19805793]
84. Torres S, Ramos M, Leverence R, Bowen D, Berwick M, Hay J. A pilot study of skin cancer risk reduction behaviors, cancer communication, and skin cancer beliefs in hispanics. Calif J Health Promot 2014;12(1):95-100 ISSN: 1545-8717 [FREE Full text]

85. McBride CM, Koehly LM, Sanderson SC, Kaphingst KA. The behavioral response to personalized genetic information: will genetic risk profiles motivate individuals and families to choose more healthful behaviors? Annu Rev Public Health 2010;31:89-103. [doi: 10.1146/annurev.publhealth.012809.103532] [Medline: 20070198]
86. Kaphingst KA, McBride CM, Wade C, Alford SH, Reid R, Larson E, et al. Patients' understanding of and responses to multiplex genetic susceptibility test results. Genet Med 2012 Jul;14(7):681-687 [FREE Full text] [doi: 10.1038/gim.2012.22] [Medline: 22481132]
87. Kaphingst KA, McBride CM, Wade C, Alford SH, Brody LC, Baxevanis AD. Consumers' use of web-based information and their decisions about multiplex genetic susceptibility testing. J Med Internet Res 2010 Sep 29;12(3):e41 [FREE Full text] [doi: 10.2196/jmir.1587] [Medline: 20884465]
88. Berrigan D, Forsyth BH, Helba C, Levin K, Norberg A, Willis GB. Cognitive testing of physical activity and acculturation questions in recent and long-term Latino immigrants. BMC Public Health 2010 Aug 13;10:481 [FREE Full text] [doi: 10.1186/1471-2458-10-481] [Medline: 20707902]
89. Harkness J, Edwards B, Braun M, Johnson TD, Lyberg L, Mohler PP, et al. Survey Methods in Multicultural, Multinational, and Multiregional Contexts. Hoboken, NJ: Wiley; 2010.
90. Willis G. Cognitive interviewing: a tool for improving questionnaire design. Thousand Oaks, CA: Sage Publications; 2005.
91. Rodríguez VM, Robers E, Zielaskowski K, Javier GC, Hunley K, Kaphingst KA, et al. Translation and adaptation of skin cancer genomic risk education materials for implementation in primary care. J Community Genet 2017 Jan;8(1):53-63 [FREE Full text] [doi: 10.1007/s12687-016-0287-z] [Medline: 27924449]
92. Davidson KW, Goldstein M, Kaplan RM, Kaufmann PG, Knatterud GL, Orleans CT, et al. Evidence-based behavioral medicine: what is it and how do we achieve it? Ann Behav Med 2003 Dec;26(3):161-171. [Medline: 14644692]
93. Schulz KF, Altman DG, Moher D. CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. J Clin Epidemiol 2010 Aug;63(8):834-840 [FREE Full text] [doi: 10.1016/j.jclinepi.2010.02.005] [Medline: 20346629]
94. Hensley-Alford S, McBride CM, Reid RJ, Larson EB, Baxevanis AD, Brody LC. Participation in genetic testing research varies by social group. Public Health Genomics 2011;14(2):85-93 [FREE Full text] [doi: 10.1159/000294277] [Medline: 20299772]
95. Brewer NT, Tzeng JP, Lillie SE, Edwards AS, Peppercorn JM, Rimer BK. Health literacy and cancer risk perception: implications for genomic risk communication. Med Decis Making 2009;29(2):157-166. [doi: 10.1177/0272989X08327111] [Medline: 19050227]
96. Lipkus IM. Numeric, verbal, and visual formats of conveying health risks: suggested best practices and future recommendations. Med Decis Making 2007;27(5):696-713. [doi: 10.1177/0272989X07307271] [Medline: 17873259]
97. Reyna VF, Lloyd FJ, Whalen P. Genetic testing and medical decision making. Arch Intern Med 2001 Nov 12;161(20):2406-2408. [Medline: 11700152]
98. Reyna VF, Lloyd FJ, Brainerd C. Memory, development, and rationality: An integrative theory of judgment and decision making. In: Schneider S, Shanteau J, editors. Emerging perspectives on judgment and decision research. Cambridge: Cambridge University Press; 2003:201-245.
99. Coyne JC, Benazon NR, Gaba CG, Calzone K, Weber BL. Distress and psychiatric morbidity among women from high-risk breast and ovarian cancer families. J Consult Clin Psychol 2000 Oct;68(5):864-874. [Medline: 11068972]
100. Bergenmar M, Hansson J, Brandberg Y. Family members' perceptions of genetic testing for malignant melanoma--a prospective interview study. Eur J Oncol Nurs 2009 Apr;13(2):74-80. [doi: 10.1016/j.ejon.2008.12.003] [Medline: 19179113]
101. Graham JW, Hofer SM, Donaldson SI, MacKinnon DP, Schafer JL. Analysis with missing data in prevention research. In: Bryant KJ, Windle MT, West SH, editors. The science of prevention: methodological advances from alcohol and substance abuse research. Washington, D.C: American Psychological Association; 1997.
102. Schafer J, Olsen M. Multiple imputation for multivariate missing data problems: a data analyst's perspective. Multivariate Behav Res 1998 Oct 01;33(4):545-571. [doi: 10.1207/s15327906mbr3304_5] [Medline: 26753828]
103. Rogers E. Diffusion of Innovations, 5th Edition. New York: Free Press; 2003.
104. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Pers Soc Psychol 1986 Dec;51(6):1173-1182. [Medline: 3806354]
105. MacKinnon D. Introduction to statistical mediation analysis. New York: Lawrence Erlbaum Associates/Taylor & Francis Group; 2008.
106. Geller AC, Emmons KM, Brooks DR, Powers C, Zhang Z, Koh HK, et al. A randomized trial to improve early detection and prevention practices among siblings of melanoma patients. Cancer 2006 Aug 15;107(4):806-814 [FREE Full text] [doi: 10.1002/cncr.22050] [Medline: 16832795]
107. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: L. Erlbaum Associates; 1988.
108. Eng TR. Emerging technologies for cancer prevention and other population health challenges. J Med Internet Res 2005 Jul 01;7(3):e30 [FREE Full text] [doi: 10.2196/jmir.7.3.e30] [Medline: 15998621]
109. Shaer O, Nov O, Okerlund J, Balestra M, Stowell E, Ascher L, et al. Informing the design of direct-to-consumer interactive personal genomics reports. J Med Internet Res 2015 Jun;17(6):e146 [FREE Full text] [doi: 10.2196/jmir.4415] [Medline: 26070951]

110. Glanz K, Yaroch AL, Dancel M, Saraiya M, Crane LA, Buller DB, et al. Measures of sun exposure and sun protection practices for behavioral and epidemiologic research. Arch Dermatol 2008 Feb;144(2):217-222. [doi: 10.1001/archdermatol.2007.46] [Medline: 18283179]
111. Ersig AL, Williams JK, Hadley DW, Koehly LM. Communication, encouragement, and cancer screening in families with and without mutations for hereditary nonpolyposis colorectal cancer: a pilot study. Genet Med 2009 Oct;11(10):728-734 [FREE Full text] [doi: 10.1097/GIM.0b013e3181b3f42d] [Medline: 19707152]
112. Hay J, Shuk E, Zapolska J, Ostroff J, Lischewski J, Brady M, et al. Family communication patterns after melanoma diagnosis. J Fam Commun 2009 Oct 09;9(4):209-232. [doi: 10.1080/15267430903182678]
113. Hay J, Ostroff J, Martin A, Serle N, Soma S, Mujumdar U, et al. Skin cancer risk discussions in melanoma-affected families. J Cancer Educ 2005;20(4):240-246. [doi: 10.1207/s15430154jce2004_13] [Medline: 16497137]
114. Hay J, Kaphingst KA, Baser R, Li Y, Hensley-Alford S, McBride CM. Skin cancer concerns and genetic risk information-seeking in primary care. Public Health Genomics 2012;15(2):57-72 [FREE Full text] [doi: 10.1159/000330403] [Medline: 21921576]
115. Yennurajalingam S, Parsons HA, Duarte ER, Palma A, Bunge S, Palmer JL, et al. Decisional control preferences of Hispanic patients with advanced cancer from the United States and Latin America. J Pain Symptom Manage 2013 Sep;46(3):376-385. [doi: 10.1016/j.jpainsymman.2012.08.015] [Medline: 23182756]
116. Witte K, Cameron KA, McKeon JK, Berkowitz JM. Predicting risk behaviors: development and validation of a diagnostic scale. J Health Commun 1996;1(4):317-341. [doi: 10.1080/108107396127988] [Medline: 10947367]
117. Waters EA, Hay JL, Orom H, Kiviniemi MT, Drake BF. "Don't know" responses to risk perception measures: implications for underserved populations. Med Decis Making 2013 Feb;33(2):271-281 [FREE Full text] [doi: 10.1177/0272989X12464435] [Medline: 23468476]
118. Weinstein ND. Unrealistic optimism about susceptibility to health problems. J Behav Med 1982 Dec;5(4):441-460. [Medline: 7154065]
119. Aiken LS, West SG, Woodward CK, Reno RR, Reynolds KD. Increasing screening mammography in asymptomatic women: evaluation of a second-generation, theory-based program. Health Psychol 1994 Nov;13(6):526-538. [Medline: 7889908]
120. Bandura A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall; 1986.
121. Hay JL, Baser R, Weinstein ND, Li Y, Primavera L, Kemeny MM. Examining intuitive risk perceptions for cancer in diverse populations. Health Risk Soc 2014 Jan 01;16(3):227-242 [FREE Full text] [doi: 10.1080/13698575.2014.911822] [Medline: 24999304]
122. Hay JL, Ramos M, Li Y, Holland S, Brennessel D, Kemeny MM. Deliberative and intuitive risk perceptions as predictors of colorectal cancer screening over time. J Behav Med 2016 Feb;39(1):65-74 [FREE Full text] [doi: 10.1007/s10865-015-9667-9] [Medline: 26280754]
123. Hay JL, Oliveria SA, Dusza SW, Phelan DL, Ostroff JS, Halpern AC. Psychosocial mediators of a nurse intervention to increase skin self-examination in patients at high risk for melanoma. Cancer Epidemiol Biomarkers Prev 2006 Jun;15(6):1212-1216 [FREE Full text] [doi: 10.1158/1055-9965.EPI-04-0822] [Medline: 16775183]
124. Chew LD, Griffin JM, Partin MR, Noorbaloochi S, Grill JP, Snyder A, et al. Validation of screening questions for limited health literacy in a large VA outpatient population. J Gen Intern Med 2008 May;23(5):561-566 [FREE Full text] [doi: 10.1007/s11606-008-0520-5] [Medline: 18335281]
125. Chew LD, Bradley KA, Boyko EJ. Brief questions to identify patients with inadequate health literacy. Fam Med 2004 Sep;36(8):588-594 [FREE Full text] [Medline: 15343421]
126. Shea JA, Micco E, Dean LT, McMurphy S, Schwartz JS, Armstrong K. Development of a revised Health Care System Distrust scale. J Gen Intern Med 2008 Jun;23(6):727-732 [FREE Full text] [doi: 10.1007/s11606-008-0575-3] [Medline: 18369678]
127. Powe BD. Cancer fatalism among elderly Caucasians and African Americans. Oncol Nurs Forum 1995 Oct;22(9):1355-1359. [Medline: 8539176]
128. National Cancer Institute. 2007. Health Information National Trends Survey URL: https://hints.cancer.gov/ [accessed 2017-01-30] [WebCite Cache ID 6nuQOUTS8]
129. Horowitz M, Wilner N, Alvarez W. Impact of Event Scale: a measure of subjective stress. Psychosom Med 1979 May;41(3):209-218. [Medline: 472086]
130. Joseph S. Psychometric evaluation of Horowitz's Impact of Event Scale: a review. J Trauma Stress 2000 Jan;13(1):101-113. [doi: 10.1023/A:1007777032063] [Medline: 10761177]
131. Thewes B, Meiser B, Hickie IB. Psychometric properties of the Impact of Event Scale amongst women at increased risk for hereditary breast cancer. Psychooncology 2001;10(6):459-468. [Medline: 11747058]
132. Nelson DE, Kreps GL, Hesse BW, Croyle RT, Willis G, Arora NK, et al. The Health Information National Trends Survey (HINTS): development, design, and dissemination. J Health Commun 2004;9(5):443-60; discussion 81. [doi: 10.1080/10810730490504233] [Medline: 15513791]
133. Gandini S, Sera F, Cattaruzza MS, Pasquini P, Abeni D, Boyle P, et al. Meta-analysis of risk factors for cutaneous melanoma: I. Common and atypical naevi. Eur J Cancer 2005 Jan;41(1):28-44 [FREE Full text] [doi: 10.1016/j.ejca.2004.10.015] [Medline: 15617989]

Abbreviations

DNA: deoxyribonucleic acid
FCDS: Florida Cancer Data System
MC1R: melanocortin-1 receptor
SEER: Surveillance, Epidemiology, and End Results
SOMBRA: Skin health Online for Melanoma: Better Risk Assessment
UNM: University of New Mexico

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