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<u>Original Paper</u>

The Impact of Participant Characteristics on Use and Satisfaction of a Web-Based Computer-Tailored Chronic Obstructive Pulmonary Disease Self-Management Intervention: A Process Evaluation

Viola Voncken-Brewster[1], PhD; Mylène Amoureus[2], MSc; Hein de Vries[3], PhD; Zsolt Nagykaldi[4], PhD; Bjorn Winkens[5], PhD; Trudy van der Weijden[1], PhD; Huibert Tange[1], PhD

[1]Department of Family Medicine, Care and Public Health Research Institute, Maastricht University Medical Center, Maastricht, Netherlands

[2]Institute of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands

[3]Department of Health Promotion, Care and Public Health Research Institute, Maastricht University Medical Center, Maastricht, Netherlands

[4]Department of Family and Preventive Medicine, University of Oklahoma Health Sciences Center, University of Oklahoma, Oklahoma, OK, United States

[5]Department of Methodology and Statistics, Care and Public Health Research Institute, Maastricht University Medical Center, Maastricht, Netherlands

Corresponding Author:
Viola Voncken-Brewster, PhD
Department of Family Medicine
Care and Public Health Research Institute
Maastricht University Medical Center
Maastricht University
PO Box 616
Maastricht,
Netherlands
Phone: 31 43 388 2230
Fax: 31 43 361 9344
Email: viola.voncken@maastrichtuniversity.nl

Abstract

Background: A randomized controlled trial (RCT) showed that a Web-based computer-tailored self-management intervention for people with or at risk for chronic obstructive pulmonary disease (COPD) did not have a significant treatment effect. Process evaluation measures such as application use and satisfaction with the intervention can help understand these results.

Objectives: The aim of this paper is to uncover reasons for suboptimal application use, evaluate satisfaction with the intervention, and investigate which participant characteristics predict application use and user satisfaction.

Methods: Participants were recruited through 2 different channels: an online panel and general practice. The intervention group received the intervention, which consisted of 2 modules (smoking cessation and physical activity). The control group received no intervention. The study employed a mixed methods design. Quantitative and qualitative data were gathered assessing participant characteristics, application use, reasons for not using the application, and satisfaction with the intervention.

Results: The RCT included 1325 participants. The proportion of individuals who participated was significantly higher in the online group (4072/6844, 59.5%) compared to the general practice group (43/335, 12.8%) ($P<.001$). Application use was low. Of all participants in the intervention group, 52.9% (348/658) initiated use of one or both modules, 36.0% (237/658) completed an intervention component (prolonged use), and 16.6% (109/658) revisited one of the modules after completing an intervention component (sustained use). Older age, established diagnosis of COPD, or experiencing breathlessness predicted sustained use. Participant satisfaction with the 2 modules was 6.7 (SD 1.6) on a scale from 0 to 10. The interviews revealed that a computer application was believed not to be sufficient and the help of a health care professional was necessary. Participants with a greater intention to change were more satisfied with the application.

Conclusions: The application was not used sufficiently. Study materials should be further tailored to younger individuals, those at risk for COPD, and those who do not experience breathlessness in order to increase sustained use among them. Involvement of a health care professional could improve satisfaction with the intervention and potentially increase engagement with the

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intervention materials. However, to make this possible, recruitment in general practice needs to be improved. Recommendations are made for improving the study design, strengthening the intervention (eg, practice facilitation), and linking the computer application to interaction with a health care provider.

Introduction

Chronic obstructive pulmonary disease (COPD) is a highly prevalent disease characterized by airway obstruction that is not fully reversible [1]. In order to decelerate the progression of the disease, interventions focusing on self-management and behavior modification such as smoking cessation and physical activity, are considered important [2,3]. Multiple COPD self-management interventions have been developed; most of these interventions include helping patients with physical activity and/or smoking behavior, but their effectiveness remains uncertain [4].

Supporting patients in improving smoking and physical activity behaviors can be achieved by using information and communication technology [5,6]. Several tools have been developed for COPD patients. For instance, one study found short-term effects of an Internet-mediated, pedometer-based walking program on daily step count and health-related quality of life [7]. However, no long-term effects were found [8]. Another study showed that a mobile activity monitoring and feedback tool for COPD and type 2 diabetes patients effectively increased physical activity when combined with counseling [9]. In the MasterYourBreath project, we developed a COPD self-management intervention using computer-tailored technology to improve smoking behavior and levels of physical activity. Computer-tailored technology makes it possible to provide individuals with computer-generated personally relevant health promotion information at their own home [5]. Relevant feedback can be given by tailoring messages to participant characteristics, which has been found to increase participant attention, appreciation, and thorough processing of information [10-12]. Computer-tailored interventions have often been used to prevent disease in the general population [13-15] and have shown to effectively aid smoking cessation and increase physical activity [16-17]. However, the results of a randomized controlled trial (RCT) testing the MasterYourBreath intervention showed no significant treatment effect of the intervention on behavior and clinical outcomes in COPD patients and people at risk for COPD [18].

The lack of treatment effect could be explained by a number of reasons related to the intervention, including suboptimal application design [19], recruitment problems [20] and inadequate use of the application [20-23]. Most of these potential problems were already detected and considered during the preparation of the RCT. For example, we had improved the user interface design during a usability study [24]. We also evaluated the feasibility of integrating the application into an existing disease management approach [25] by conducting a pilot study

[26]. In the pilot study, participants were recruited in family practices by mediation of the practice nurse, which did not result in the required number of respondents. To improve study participation during the RCT, we broadened the recruitment strategy by including people at risk for COPD in addition to diagnosed COPD patients, inviting patients from general practices by mail, and by recruiting people from an online panel. This strategy improved the reach of our target population, but hindered our plans for integrating the MasterYourBreath intervention into primary care [18]. A problem we were not able to solve adequately was the suboptimal use of the application. We included several evidence-based measures to promote application use during the RCT [18] based on results of the pilot study [26]. However, application use was still low [18], which could be a potential explanation for the nonsignificant effect on primary outcomes in the RCT. Protocol analyses including only participants who used main components of the intervention showed no significant effects on smoking cessation and physical activity, possibly due to the limited sample size and thus decreased power of the study. However, a trend was found for an increased effect size for smoking cessation and physical activity, which was related to the number of completed intervention components [18]. We were not able to determine the threshold for sufficient application use, but the completion of more components was associated with an increased treatment effect.

Considering application use, it is important to understand which intervention characteristics and participant characteristics are associated with the adoption of the intervention materials, as explained in the diffusion of innovation theory [27]. It is important to know which intervention characteristics were appreciated, who visited and revisited the application, and which participant characteristics were associated with satisfaction in order to explain use rates and develop better strategies to increase application use. To our knowledge, no studies have been conducted investigating which participant characteristics predict the use and satisfaction of online health promotion interventions in COPD patients. Studies focusing on online health promotion applications in other target populations show mixed results [28-30]. For example, Brouwer et al [28] found that younger women with a medium-to-high education level were more likely to use behavior modules. Stretcher et al [30] found the same for gender and education level but the opposite for age, as an older age was positively associated with application use. The study of Schneider at al [29] also showed a positive impact of older age on module use. However, contrary to the other studies, this study found that men were more likely to use the modules. Another interesting finding was that participants with a relatively unhealthy lifestyle and low income

were more likely to initiate a module, but they were less likely to complete a module.

In this paper, we report the results of a process evaluation, conducted in conjunction with the RCT of the MasterYourBreath intervention, in order to examine possible reasons for insufficient use of the application and to explore user satisfaction. The evaluation focused on suboptimal application use and user satisfaction in general and the influence of participant characteristics on application use and user satisfaction.

Methods

Study Design

The process evaluation study was conducted as part of an RCT examining the effect of a computer-tailored self-management intervention targeting smoking cessation and level of physical activity [18,31]. A mixed methods study design was employed using quantitative and qualitative data complementarily. The study applied a triangulation design model [32], in which the quantitative and qualitative data were integrated during the interpretation phase to understand the reasons for suboptimal use and to evaluate satisfaction. Data collection started in May 2012 and ended in July 2013, concurrent with the data collection of the RCT. The study was approved by the Medical Ethical Committee of Maastricht University Medical Center (METC 12-4-033) as part of the RCT.

Recruitment

Adults between 40 and 70 years of age were eligible to participate if they were diagnosed with COPD or were at moderate or high risk for COPD, were proficient in Dutch, had access to the Internet and had basic computer skills. The Respiratory Health Screening Questionnaire (RHSQ) [33] was administered to determine if individuals were at moderate or high risk for COPD. Participants were recruited from 5 family practices that were involved in another study in which patients were screened for COPD by their general practitioner using the RHSQ [34] and from members of an existing Dutch online panel assembled by Flycatcher (www.flycatcher.eu), an International Organization for Standardization–certified institute for online research. Patients of the family practices received a paper invitation letter and were not compensated for the study. Members of the online panel received an invitation by email and were compensated with a small incentive equal to €2.55 (US $3) per completed questionnaire. A reminder was sent to those who did not reply to the study invitation. Participants were only compensated for completing baseline and follow-up questionnaires and not for using the MasterYourBreath application. All participants received a study information letter and completed an informed consent form before entering the study. Participants were randomly allocated to the intervention and control groups. Participants in the intervention group received the MasterYourBreath intervention. Participants in the control group received no intervention and did not have access to the website.
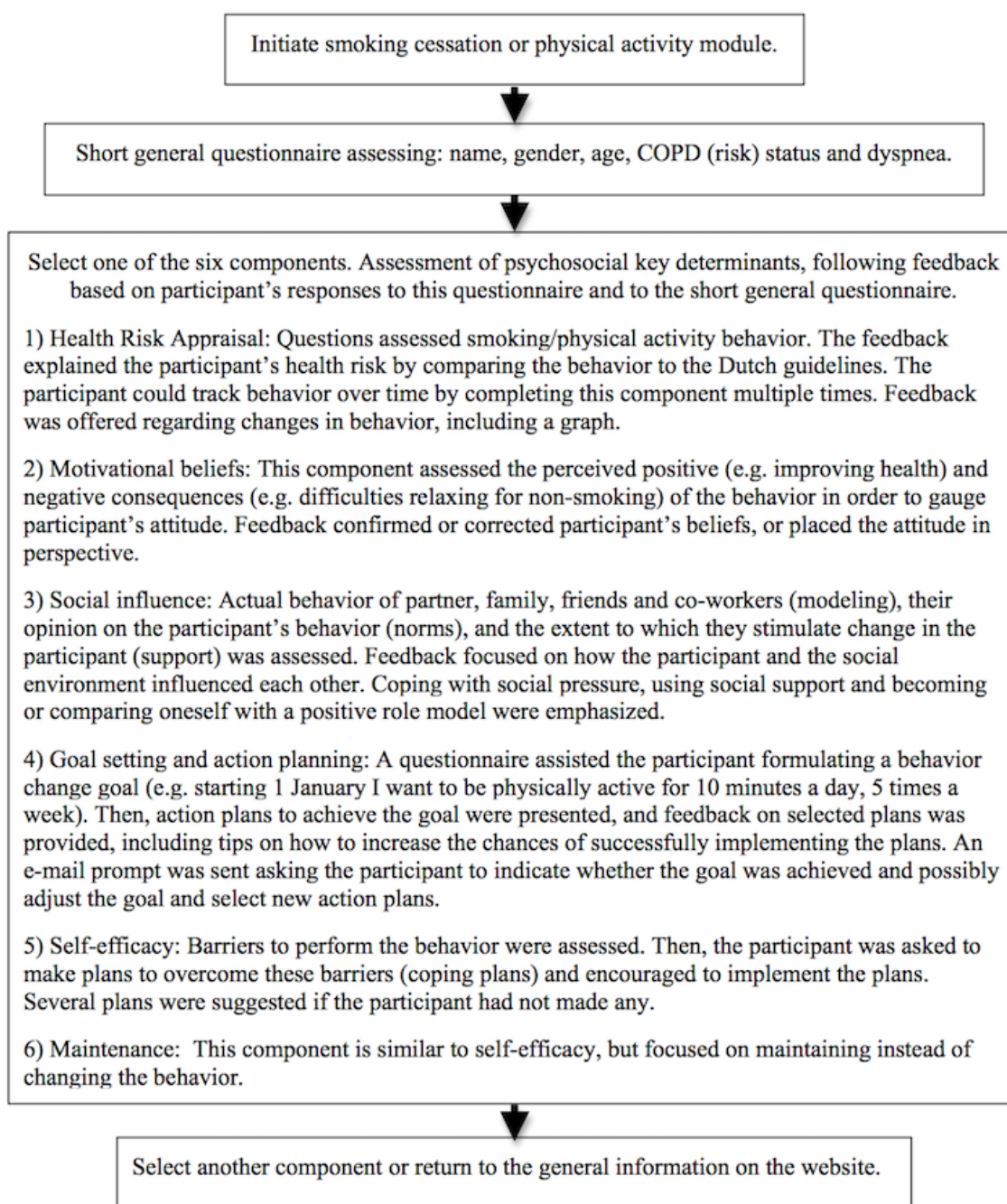
MasterYourBreath Intervention

The intervention aimed to improve smoking cessation and physical activity by means of a Web-based application. One module was developed for each behavior, based on previously developed interventions [11,35,36] and adjusted for the target population. The I-change model [37,38] was used as the theoretical framework for this intervention. This model is the successor of the attitude-social influence-self-efficacy model [39] and incorporates several theoretical concepts from sociocognitive models such as the theory of planned behavior [40], social cognitive theory [41], transtheoretical model [42], health belief model [43], and implementation and goal-setting theories [44-45].

The 2 modules (smoking cessation and physical activity) consisted of 6 intervention components each: (1) health risk appraisal, (2) motivational beliefs, (3) social influence, (4) goal-setting and action plans, (5) self-efficacy in order to change behavior, and (6) self-efficacy in order to maintain behavior. Participants could switch between the smoking cessation and physical activity modules and choose to enter one or more intervention components at their preference [10]. Intervention components were available to be completed as often as participants chose over the course of the study.

Each component provided participants with computer-generated tailored feedback based on participant responses to questionnaires. The feedback was personalized using participant names and tailored to participant characteristics including gender, age, COPD (risk) status, and level of disability. For example, feedback focused on stopping disease progression for COPD patients, while feedback for participants at risk for COPD focused on disease prevention. Feedback for COPD patients also acknowledged that COPD can limit their physical abilities, and feedback included suggestions to improve physical activity accordingly. Feedback was also tailored to behavior determinants based on psychosocial constructs. For example, barriers to quit smoking and plans to overcome these barriers were assessed and feedback was provided in order to increase participant self-efficacy [24]. In addition, participants could track their own behavior change and goal attainment, as the feedback compared previous responses to the most current responses. See Figure 1 for an overview of the main intervention content.

The behavior change modules for smoking cessation and physical activity were embedded in a website. The website offered participants information about the MasterYourBreath project, COPD, risk for COPD, smoking, and physical activity. The website also included nontailored self-management resources such as home exercise videos and hyperlinks to other informative websites. The website was not part of the core intervention content but was meant to attract participants and improve the user experience. Tailored feedback was kept as short as possible by referring to information and self-management resources on the website. The website was updated regularly with new information to maintain participant interest in the application [46-48].

Figure 1. Overview of the main intervention content.


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│         Initiate smoking cessation or physical activity module.   │
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                              ↓
┌─────────────────────────────────────────────────────────────────┐
│  Short general questionnaire assessing: name, gender, age, COPD    │
│  (risk) status and dyspnea.                                        │
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Select one of the six components. Assessment of psychosocial key determinants, following feedback based on participant's responses to this questionnaire and to the short general questionnaire.

1) Health Risk Appraisal: Questions assessed smoking/physical activity behavior. The feedback explained the participant's health risk by comparing the behavior to the Dutch guidelines. The participant could track behavior over time by completing this component multiple times. Feedback was offered regarding changes in behavior, including a graph.

2) Motivational beliefs: This component assessed the perceived positive (e.g. improving health) and negative consequences (e.g. difficulties relaxing for non-smoking) of the behavior in order to gauge participant's attitude. Feedback confirmed or corrected participant's beliefs, or placed the attitude in perspective.

3) Social influence: Actual behavior of partner, family, friends and co-workers (modeling), their opinion on the participant's behavior (norms), and the extent to which they stimulate change in the participant (support) was assessed. Feedback focused on how the participant and the social environment influenced each other. Coping with social pressure, using social support and becoming or comparing oneself with a positive role model were emphasized.

4) Goal setting and action planning: A questionnaire assisted the participant formulating a behavior change goal (e.g. starting 1 January I want to be physically active for 10 minutes a day, 5 times a week). Then, action plans to achieve the goal were presented, and feedback on selected plans was provided, including tips on how to increase the chances of successfully implementing the plans. An e-mail prompt was sent asking the participant to indicate whether the goal was achieved and possibly adjust the goal and select new action plans.

5) Self-efficacy: Barriers to perform the behavior were assessed. Then, the participant was asked to make plans to overcome these barriers (coping plans) and encouraged to implement the plans. Several plans were suggested if the participant had not made any.

6) Maintenance: This component is similar to self-efficacy, but focused on maintaining instead of changing the behavior.

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                              ↓
┌─────────────────────────────────────────────────────────────────┐
│  Select another component or return to the general information on  │
│  the website.                                                      │
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Participants in the intervention group received an email invitation to use the application ad libitum for 6 months. They could access the application online with their personal account information, which was included in the email. If they did not use a behavior change module within 2 weeks after receiving the invitation, they were prompted by email. Another prompt was sent 2 weeks later if they did not respond to the first prompt. The 2-week time interval has shown to be optimal [49]. If participants had visited one of the two modules, prompts were sent every month to encourage revisits, so participants visiting both modules received a prompt approximately every 2 weeks. These prompts contained an option for participants to stop receiving future prompts. Prompts were tailored to COPD or individuals at risk for COPD and the selected behavior (smoking cessation or physical activity). Prompts included information to attract participants to the application—for example, by referring to new content on the website [49]. Participants who formulated concrete behavior-change goals received one email prompt 1 week after their goal was due. A more detailed description of the intervention can be found in the study protocol [31].

Data Collection

Quantitative Data

A Web-based questionnaire was administered at baseline and after the 6-month intervention period. Demographic antecedents were gathered from an online database (online panel group) or as part of the baseline Web-based questionnaire (general practice

group). Application use of each participant was monitored by the system.

Qualitative Data

The Web-based questionnaire also contained a comment section in which participants could voice their opinion about the application. The research team took field notes concerning the recruitment procedure and other communications with participants. Semistructured face-to-face interviews with 10 participants who used the MasterYourBreath application were conducted by an independent researcher (Mylène Amoureus). In order to create a heterogeneous sample, the interviewees were selected based on recruitment channel (online panel or general practice), age, gender, COPD (risk) status, education level, and smoking status. The interviews took place after the intervention period. During the interview, participants were asked to use the application in order to refresh their memory. Interviewees received a €25 (US $29) voucher.

Measures

Participant Characteristics

Participant characteristics included personal, health status, and health behavior characteristics. Personal characteristics were gender, age, and education level (recoded as "low," 1=primary school/basic vocational school; "medium," 2=secondary vocational school/high school degree; and "high," 3=higher professional degree/university degree). Health status characteristics were COPD status (coded as diagnosed with COPD or at risk for COPD) and dyspnea status, measured by the Medical Research Council (MRC) dyspnea score [50] (1 to 5, higher score means worse dyspnea). Health behavior characteristics included current smoking status (smoking/not smoking), level of physical activity assessed by the International Physical Activity Questionnaire–Short Form (IPAQ-SF) metabolic equivalent task (MET) minutes per week [51], intention to quit smoking, and intention to increase physical activity, both measured on a 1-item 7-point Likert scale (1=I certainly plan to quit smoking/to be more physically active; 7=I certainly do not plan to quit smoking/to be more physically active).

Application Use

Application use was defined as use of the core intervention content (ie, the 6 components of both the smoking cessation and physical activity modules). Visits to the nontailored general information on the website were not counted. Three quantitative measures were used to assess application use. The first measure was initial use, defined as participants initiating the smoking cessation or physical activity module at least once. The second measure was prolonged use, defined as participants who completed at least one intervention component as part of the smoking cessation or physical activity module. The third measure was sustained use, defined as participants who completed at least one intervention component of the smoking cessation or physical activity module and then initiated either module at least once more later in the study. On the Web-based questionnaire, an option was provided to indicate that participants did not visit the website, so those who did not use or did not recall using the application could be excluded from

further questions regarding satisfaction with the application. These participants received a question with predetermined response categories concerning their reasons for not using the modules (not enough time; because I live healthy; not necessary, because I think I am not at risk for or I do not have COPD; I wanted to visit the website, but I could not log in to the website; other reason). The perceived influence of updating and adding new information to the website and sending periodic email prompts on application use was examined qualitatively during the interviews.

Satisfaction With the Intervention Content

Quantitative measures for satisfaction with the application included 7 questions on a 5-point Likert scale, ranging from 1=totally disagree to 5=totally agree and 1 question on a 10-point scale. These questions were largely based on earlier work of de Vries et al [11]. The 5-point questions assessed appreciation of the website (navigation), the tailored feedback (comprehensibility, novelty, usefulness, and personalization), and the application in general (recommendable to others, intention for future use). The 10-point question assessed overall satisfaction with the tailored feedback (1=very bad to 10=very good). Satisfaction with the application was further explored qualitatively during the interviews using the above-described topics as lead questions. The Web-based questionnaire asked participants to comment on their opinion of the application.

Data Analyses

Quantitative Analyses

Categorical variables were represented by number and percentage and numerical variables by mean and standard deviation (SD) or median and interquartile range (IQR). To determine whether selective missingness had occurred for the outcomes satisfaction with the application and physical activity, we conducted chi-square tests for categorical and independent samples t tests for numerical baseline characteristics. Differences between the 2 recruitment channels regarding study participation and retention of the overall sample (control and intervention group) were assessed with chi-square tests. All further analyses only included the intervention group. Differences between the 2 recruitment channels regarding baseline characteristics were analyzed with chi-square tests, Fisher's exact tests, or Fisher-Freeman-Halton tests for categorical variables and independent samples t tests or Mann-Whitney U tests for numerical variables. Logistic regression analysis and linear mixed models analysis were performed to determine the influence of satisfaction on the primary outcomes of the RCT, which were 7-day point abstinence for smoking cessation (0=did not refrain from smoking during the last 7 days or 1=refrained from smoking during the last 7 days) and MET minutes per week for physical activity measured at baseline and after 6 months. Linear mixed models were used for the physical activity to account for the correlation between repeated measurements of the same participant. As for correction, the models included baseline variables that were related to missing data. Multiple logistic and linear regression analyses were performed to assess differences in use and satisfaction in the intervention group, respectively, according to participant characteristics. Initial, prolonged, and sustained use (0=no or 1=yes) were the

dependent variables to assess differences in use. The dependent variable to assess differences in satisfaction was overall satisfaction rated on a scale of 1 to 10. The following participant characteristics were included as predictors in each model: age, gender, education level, COPD status, dyspnea status (coded as 0=participants who scored 1 to 5 on the MRC dyspnea score and 1=participants who indicated experiencing no breathlessness), smoking status, level of physical activity, and the intention to quit smoking or increase physical activity (whichever intention was the highest). Only participants who completed at least one intervention component and consequently had received tailored feedback were included in analyses concerning satisfaction with feedback. Independent variables were checked for multicollinearity, where a variance inflation factor of >10 indicates a collinearity problem [52]. Missing values were imputed for the level of physical activity (covariate) and the level of satisfaction (outcome variable). Multiple imputation technique was used separately for the logistic regression analyses concerning usage outcomes (initial, prolonged, and sustained use) and for the linear regression analyses concerning satisfaction, with each 100 imputations and 100 iterations, using all variables in the multiple regression model (outcome as well as independent variables) as predictors for the missing values. All statistical analyses were performed using SPSS version 19 (IBM Corp).

Qualitative Analyses

Field notes of communication between participants and the research team and comments in the Web-based questionnaire were reviewed. Interviews were transcribed verbatim and content analysis was performed using the constant comparative method [53]. Using open coding, descriptive codes were assigned, compared, and contrasted to simultaneously define and refine their properties, subcategories, and categories. Coding took place by 2 researchers (Viola Voncken-Brewster and Mylène Amoureus) independently. Analytical sessions were held after every 2 to 3 interviews, in which the 2 researchers discussed the codes and analyses. New interviews and analytical sessions were planned until consensus and data saturation were reached. The outcomes of these sessions were discussed with Huibert Tange, Trudy van der Weijden, and Hein de Vries in order to integrate these results with the quantitative results and aid understanding of the research problems.

Results

Participant Characteristics

A total of 1325 participants completed the baseline questionnaire and were randomly assigned to the intervention (n=662) and control group (n=663), of which 1307 (98.6%) participants were included in the analysis (658/662, 99.4%, in the intervention group and 649/663, 97.9%, in the control group). Figure 2 shows the Consolidated Standards of Reporting Trials diagram as shown in the RCT results article [18].

In the online group, 59.5% (4072/6844) of invited individuals completed the baseline questionnaire. In the general practice group, only 12.8% (43/335) of invited individuals completed the baseline questionnaire, which is significantly lower (*P*<.001). A priori, both groups differed in COPD status. In the online group, the COPD screening test (RHSQ) was part of the baseline questionnaire, and afterwards only 31.5% (1282/4072) were eligible for the study. A total of 18 participants of the online group were excluded from analyses due to a high level of suspicion of interference by someone other than the participant; consequently, 1264 participants were included in analyses. Interference was suspected when at least 2 of the following variables did not match their Flycatcher profile on the follow-up questionnaire: sex, day of birth, year of birth. If only one variable was inconsistent or day and month were reversed, we suspected a typing error and did not exclude those participants. The general practice group was already screened by their general practitioner, and only eligible patients received an invitation. Retention was higher in the online group (*P*<.001), where after excluding the 18 participants, 81.5% (1030/1264) of participants completed the follow-up questionnaire, compared to 53.5% (23/43) of participants in the general practice group.

Due to the low response rate in the general practice group, the reminder protocol was adjusted for this group. Participants who responded confirmative to the invitation or reminder received 2 additional reminders by email if they had not completed the baseline questionnaire. They also received 2 reminders instead of one for the follow-up questionnaire. Table 1 presents the baseline participant characteristics of the intervention group overall and the online panel and general practice group separately. The only significant differences between the 2 groups were educational level (*P*=.049) and intention to quit smoking (*P*=.01).

Characteristics of Interviewees

The age of the 10 participants who were interviewed ranged from 42 to 69 (median 58) years. There were 5 male and 5 female participants, 3 were smokers and 7 did not smoke, 6 were diagnosed with COPD and 4 were at increased risk for COPD. Education level varied—3 had a high level, 4 an intermediate level, and 3 a low level of education. A total of 7 participants were from the online panel group and 3 from the general practice group.

Figure 2. Consolidated Standards of Reporting Trials diagram, as shown in RCT results article [18].
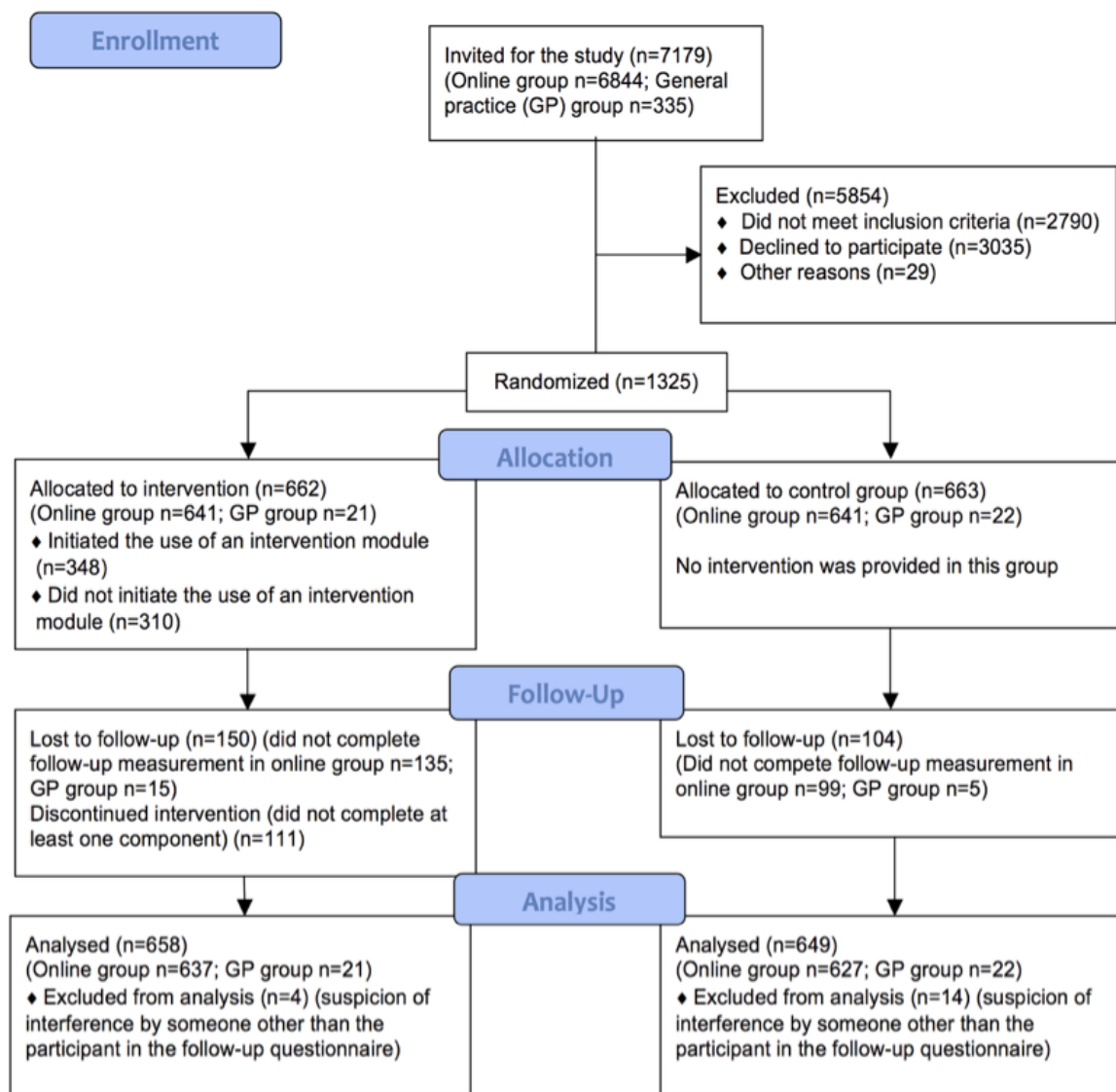
Table 1. Baseline characteristics of participants of the intervention group—overall, general practice and online group.

Characteristic	Intervention group overall (n=658)	Intervention group general practice (n=21)	Intervention group online (n=637)	P value
Age, years, mean (SD)[a]	57.7 (7.3)	58.6 (8.6)	57.7 (7.3)	.55
Male, n (%)[b]	326 (49.5)	11 (52.4)	315 (49.5)	.79
Education level, n (%)[b]				.049
Primary school/basic vocational school	191 (29.0)	10 (47.6)	181 (28.4)	
Secondary vocational school/high school degree	209 (31.8)	2 (9.5)	207 (32.5)	
Higher professional degree/university degree	258 (39.2)	9 (42.9)	249 (39.1)	
COPD[d] status, n (%)[c]				.06
Diagnosed with COPD	146 (22.2)	1 (4.8)	145 (22.8)	
Increased risk for COPD per RHSQ[e]	512 (77.8)	20 (95.2)	492 (77.2)	
MRC[f] dyspnea (n=657)[g], n (%)				.11
No breathlessness	177 (26.9)	8 (40.0)	169 (26.5)	
1	264 (40.2)	9 (45.0)	255 (40.0)	
2	167 (25.4)	1 (5.0)	166 (26.1)	
3	34 (5.2)	1 (5.0)	33 (5.2)	
4	9 (1.4)	1 (5.0)	8 (1.3)	
5	6 (0.9)	0 (0.0)	6 (0.9)	
Smoking status, n (%)[b]				.09
Currently smoking	241 (36.6)	4 (19.0)	237 (37.2)	
Currently not smoking	417 (63.4)	17 (81.0)	400 (62.8)	
Intention to quit smoking (1=highest intention, 7=lowest intention) among smokers (n=241), median (IQR[h])[i]	4.0 (2.0-5.5)	1.0 (1.0-1.8)	4.0 (2.0-6.0)	.01
Level of physical activity (MET[j] per week) (n=555), median (IQR)[i]	2904.0 (1200.0-5758.0)	3036.0 (74.3-4518.8)	2904.0 (1212.-5787.5)	.36
Intention to be more physically active (1=highest intention, 7=lowest intention), median (IQR)[i]	3.0 (2.0-4.0)	3.0 (1.0-4.5)	3.0 (2.0-4.0)	.64

[a]Independent samples *t* test.

[b]Chi-square test.

[c]Fisher's exact test.

[d]COPD: chronic obstructive pulmonary disease.

[e]RHSQ: Respiratory Health Screening Questionnaire.

[f]MRC: Medical Research Council.

[g]Fisher-Freeman-Halton test.

[h]IQR: interquartile range.

[i]Mann Whitney U test.

[j]MET: metabolic equivalent task.

Application Use

Quantitative Results

Initial Use

A total of 52.9% (348/658) of the intervention group started at least one of the two modules, with an average of 2.0 (SD 2.1, range 1 to 20) initiations in this group. The smoking module was initiated by 33.2% (80/241) of smokers and the physical activity module by 44.7% (294/658) of participants (both smokers and nonsmokers). The smoking cessation module was also initiated by 7.2% (30/417) of nonsmokers. Participant characteristics did not predict initial use significantly (Table 2). Of the participants who initiated use, 23.6% (82/348) indicated at some point during the intervention period that they did not want to receive prompts any longer.

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Prolonged Use

As described earlier [18], of all participants in the intervention group, 36.0% (237/658) completed at least one intervention component. This group completed on average 2.1 (SD 2.4, range 1 to 21) components. At least one component of the smoking cessation module was completed by 21.2% (51/241) of smokers, and 29.3% (193/658) of participants completed a component of the physical activity module. A total of 1.7% (7/417) of nonsmokers completed at least one component of the smoking cessation module. None of the participant characteristics were significant predictors of prolonged use (Table 2). Table 3 shows how often the individual components of each module were completed and the proportion of each completed component compared to the total number of all completed components in each module.

Sustained Use

A total of 16.6% (109/658) of participants revisited the intervention content. They initiated one of the two modules after they had finished an intervention component of either module earlier in the study. Older participants, those diagnosed with COPD, and participants who reported breathlessness (MRC score ≥1) were significantly more likely to revisit the intervention content (Table 2). For physical activity, 3.0% (20/658) of participants used the health risk appraisal component more than once. The goal setting and action planning component was completed several times by 2.3% (15/658) of participants. For smoking cessation, 0.8% (2/241) of smokers completed the health risk appraisal component multiple times, and 2.5% (6/241) of smokers completed the goal setting and action planning component more than once.

Table 2. Results of logistic and linear regression analyses of participant characteristics with initial use, prolonged use, sustained use, and satisfaction as dependent variables. VIF[a]≤1.32.

	Initial use (N=657)		Prolonged use (N=657)		Sustained use (N=657)		Satisfaction[b] (N=237)	
	OR[c] (95% CI[d])	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value	Regression coefficient[e] (95% CI)	*P* value
Gender (female vs male)	0.98 (0.83-1.15)	.89	1.19 (0.84-1.68)	.32	1.12 (0.90-1.41)	.61	–0.21 (–0.69 to 0.28)	.40
Age	1.01 (0.99-1.03)	.35	1.02 (0.99-1.04)	.18	1.04 (1.02-1.05)	.02	–0.02 (–0.05 to 0.02)	.38
COPD[f] status (COPD vs at risk for COPD)	1.39 (0.96-2.02)	.10	1.38 (0.93-2.05)	.11	1.83 (1.15-2.91)	.01	–0.16 (–0.69 to 0.36)	.55
Education level (low vs high)	0.96 (0.64-1.42)	.82	0.71 (0.47-1.09)	.12	0.82 (0.47-1.44)	.48	0.56 (–0.07 to 1.18)	.08
Education level (medium vs high)	1.45 (0.982.1-4)	.06	1.29 (0.87-1.90)	.20	1.36 (0.83-2.22)	.23	0.40 (–0.15 to 0.96)	.16
Smoking status (smoking vs not smoking)	0.77 (0.56-1.06)	.13	0.76 (0.54-1.08)	.14	0.72 (0.57-0.92)	.18	–0.17 (–0.72 to 0.39)	.56
Level of physical activity (MET[g] per week)	1.00 (1.00-1.00)	.69	1.00 (1.00-1.00)	.57	1.00 (1.00-1.00)	.88	0.00 (0.00-0.00)	.93
Intention change behavior (1=highest intention, 7=lowest intention)	0.93 (0.85-1.03)	.15	0.93 (0.84-1.03)	.14	0.89 (0.78-1.02)	.08	–0.18 (–0.32 to –0.03)	.02
Dyspnea status (no breathlessness vs breathlessness)	1.01 (0.70-1.45)	.97	0.71 (0.48-1.04)	.08	0.55 (0.31-0.96)	.04	–0.43 (–1.01 to 0.15)	.15

[a]VIF: variance inflation factor.

[b]Only participants who completed at least one intervention component were included in this analysis.

[c]OR: odds ratio.

[d]CI: confidence interval.

[e]Linear regression coefficient indicates the effect of this variable on satisfaction after correction for the other variables in the model.

[f]COPD: chronic obstructive pulmonary disease.

[g]MET: metabolic equivalent task.

Table 3. Total number of completed components for each module.

	Health risk appraisal n (%)	Motivational beliefs n (%)	Social influence n (%)	Goal setting and action planning n (%)	Self-efficacy to change or maintain behavior n (%)
Physical activity	141 (37.9)	64 (17.2)	14 (3.8)	86 (23.1)	67 (18.0)
Smoking	10 (8.1)	16 (12.9)	13 (10.5)	48 (38.7)	37 (29.8)

A total of 130 participants reported that they did not log in to the website. The following reasons for not using the website were given (some participants gave multiple reasons): 26.9% (35/130) of participants did not have enough time; 23.8% (31/130) found it not necessary because they lived healthy; 27.7% (36/130) did not think it was necessary because they thought they were not at risk for or did not have COPD; 9.2% (12/130) of participants wanted to visit the website but could not log in; 19.2% (25/130) of participants gave other reasons. For example, they forgot about the website or they felt too confronted or were not ready to change behavior.

Qualitative Results

The interviews revealed that adding new information to the website led to more application use. One interviewee indicated that he might have used the application more often if it would have been available as a smartphone application.

> *An app...stimulates you more to use it, because you walk around with that thing [smartphone] all the time.*

Opinions about the periodic prompts to increase the use of the application were positive except for interviewees who were not satisfied with the application. One participant suggested sending prompts directly to his smartphone instead of through email to his computer. He also would have liked the possibility to change the prompt frequency to his preferences.

> *I think that you have to make the website that you can select yourself how often you want to receive an email prompt.*

Satisfaction

Quantitative Results

Selective missingness did not occur; we found no significant differences in characteristics of participants who completed the process evaluation questionnaire compared to participants who did not complete this questionnaire. Table 4 shows the results

concerning satisfaction. A total of 80.1% (257/321) of participants who used the website agreed (ie, 4=agree or 5=totally agree on the Likert scale) that it was easy to navigate the website. In total, 78.9% (135/171) of participants who completed at least one intervention component thought the tailored feedback was clear, 23.2% (40/172) agreed that the messages contained new information, 39.5% (68/172) indicated that these helped them live healthier, and 32.2% (55/171) thought that the feedback was personally relevant. A total of 56.6% (193/341) of participants who visited the website would recommend the application to others, and 32.3% (108/334) would like to use it in the future. Participants who completed at least one intervention component gave the feedback an average score of 6.7 (SD 1.6) on a scale from 1 to 10. Satisfaction with the intervention content did not have a significant impact on the primary outcomes of the RCT for smoking cessation (OR 1.30, 95% CI –0.59 to 2.87, P=.51) and physical activity (estimated mean difference 0.20, 95% CI –329.77 to 403.02, P=.84). Regarding the influence of participant characteristics on satisfaction, multiple linear regression analysis showed that participants with greater intention to change behavior rated the tailored feedback higher (Table 2).

Qualitative Results

Overall, participants were satisfied with the usability of the website and clarity of the tailored feedback. However, some questions were perceived to be hard to answer. One interviewee indicated that this could result in misinterpretations, which would compromise the accuracy of the tailored feedback. All interviewees except for one suggested that the information given in the tailored feedback was mostly not new to them. However, some of the participants still found the information useful, since it gave good attainable advice, confirmed their knowledge, provided support, and prompted behavior change.

> *Yes, I already knew that...but yes, it provided support.*

Table 4. Results of the satisfaction questionnaire.

	Mean (SD)	Answer categories (%)				
		1	2	3	4	5
It was easy to find information on the website (1=totally disagree, 5=totally agree), (n=321)[a]	4.0 (0.8)	4.4	6.5	9.0	50.8	29.3
The tailored feedback was clear (1=totally disagree, 5=totally agree), (n=171)[b]	4.0 (0.8)	2.3	1.2	17.5	56.7	22.2
The tailored feedback contained information that was new to me (1=totally disagree, 5=totally agree), (n=172)[b]	2.8 (1.0)	8.1	30.2	38.4	20.3	2.9
The tailored feedback helped me to live healthier (1=totally disagree, 5=totally agree), (n=172)[b]	3.1 (1.0)	8.7	14.5	37.2	34.9	4.7
The tailored feedback was personally relevant to me (1=totally disagree, 5=totally agree), (n=171)[b]	2.9 (1.0)	9.9	22.8	35.1	29.2	2.9
I would recommend MasterYourBreath to others (1=totally disagree, 5=totally agree), (n=341)[a]	3.5 (9.2)	3.8	7.3	32.3	46.0	10.6
I would like to use MasterYourBreath in the future (1=totally disagree, 5=totally agree), (n=334)[a]	3.0 (9.8)	9.0	18.0	40.7	29.0	3.3
Rating of tailored feedback on a scale of 1 to 10 (1=very bad, 10=very good), (n=182)[b]	6.7 (1.6)	—	—	—	—	—

[a]Only participants who indicated they visited the website were included in the analysis.

[b]Only participants who completed at least one intervention component were included in the analysis.

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Reasons for finding the application not useful included already maintaining a healthy lifestyle, not noticing any progress or effect on health, not being able to decrease medication use, and not believing that a computer program can help change behavior.

> *Because I did not really notice any progress or anything, I was not very motivated to continue [MasterYourBreath]*

Opinions about personalization of the tailored feedback were mixed. Suggestions were given such as focus more on comorbidities and rehabilitation therapy. Some participants indicated that the feedback was personal, and one participant mentioned that the feedback was equal to a health care professional's advice. Advantages of using the computer were being able to access the application any time and receiving a good overview of the information, which made it easier to process and remember. On the other hand, it was often indicated that automated computer feedback could never be personal enough and that a conversation with a health care professional would be preferred or should be added to the intervention.

> *It's hard to influence patients from a distance by computer...I'd rather talk 5 minutes to my general practitioner than sit behind a computer.*

Interviewees would recommend the application especially to skilled computer users with an unhealthy lifestyle or lung complications. Interviewees who found the application useful indicated that they wanted to keep using it in the future, while others did not. One participant emailed the research team that the results of the RHSQ could scare people unnecessarily. It was also mentioned in the comment section of the Web-based questionnaire that it felt like COPD was imposed upon people.

> *It sometimes seemed like they want to talk you into having COPD.*

Discussion

Principal Findings

This process evaluation explored application use and satisfaction with the MasterYourBreath intervention in order to uncover possible reasons for insufficient use of the application, which could partly explain the lack of treatment effect in the RCT [18]. Results showed that only half of the participants in the intervention group initiated one of the modules. In addition, participants did not use a significant part of the intervention content, as only 36.0% of participants completed at least one component and 16.6% revisited the intervention.

The RCT included the following evidence-based measures to promote application use: sending email prompts to participants [49]; updating and adding new information to the website regularly [46-48]; dividing the application into small components, since participants were apprehensive about the length of the application during the usability [24] and pilot study [26]; and including interactive behavior change strategies with multiple feedback moments, such as the possibility to monitor behavior change and track goal achievement over the course of the study [46,48]. Only participants who found the application helpful indicated that sending periodic email prompts and updating the website regularly were beneficial for increasing application use. A suggestion to increase use was to develop a MasterYourBreath application for smartphone and provide an option to select a prompt frequency to one's preference. As described elsewhere [18], shortening the application by giving participants the opportunity to choose intervention components might have led to a decrease in application use as more freedom in navigation leads to less application use [54,55] and similar studies that directed participants through an intervention pathway yielded positive treatment results [11,17,35,36,56-58]. Monitoring progress was given as an option. Yet only a limited number of participants initiated these components, and few used these components multiple times. Future interventions may therefore provide this information as part of the standard feedback, because facilitating self-monitoring of behavior and progress toward goals have also been found to be powerful behavior change techniques [59]. Freedom of navigation could thus also be an explanation for why the components related to monitoring behavior and tracking goal attainment did not have the anticipated positive effect on application use. Directing participants through a specified intervention pathway might improve the use of these components. It was also interesting that participants chose the social influence component least of all components. We expected this, as results of the usability and pilot study showed that participants thought that the norms and behavior of others were irrelevant to the participants' behavior change process [24,26]. Nevertheless, it is important to include a social support component and promote its use, since a meta-analyses of COPD smoking cessation interventions showed that "advice on/facilitate use of social support" was one of the few effective behavior change techniques [59]. Hence, the identification of strategies that increase the attractiveness of social support components for this group may be a first essential step toward promoting use of these components.

Reasons for Low Application Use

Several causes for low application use were identified. First, examining the participant characteristics in relation to application use, we found that being diagnosed with COPD, experiencing breathlessness, or being of an older age was linked to revisiting the intervention content (sustained use). Meanwhile, over a quarter of the participants who did not use the application indicated that not being diagnosed with COPD and believing not to be at risk for COPD were the reasons for this. Participants who were not diagnosed with COPD, were of a younger age, and did not experience breathlessness might have dismissed the opportunity to use or revisit the application because they felt that the application was not relevant for them. However, the application could especially benefit these groups, since early smoking cessation is extremely important for achieving a better health status and improving life expectancy in individuals susceptible for airflow obstruction [60]. We suspect that the lower application use in these groups could have been caused by insufficient tailoring of the study invitation and application for participants who were younger, only at risk of COPD, and did not experience breathlessness. Although the main intervention content (the smoking cessation and physical activity module) was tailored to these groups, the study invitation and general information on the website were not. The overall focus of the information was on COPD; while this is relevant for

COPD patients, it can be experienced negatively by others, as our qualitative data show. Instead, information should focus more on smoking cessation and changes in physical activity and their health benefits in general. The information on COPD and the link between lifestyle behaviors and COPD should still be provided, but this could be limited to a few sections. The importance of early smoking cessation should be emphasized in these groups so the relevance of the application will be more evident for participants who are younger, only at risk for COPD, and who do not experience breathlessness.

The second reason for low application use was that participants indicated that they did not need the application because they found that their lifestyle was healthy. However, our results based on smoking cessation and physical activity data did not confirm an influence of lifestyle on application use. It seems therefore that participants might have used their belief in a healthy lifestyle as an explanation for the lack of need for change. According to our data, 42% of the participants who indicated that their lifestyle was healthy smoked or did not adhere to the physically activity norm (defined as being physically active at least 5 days a week, 30 minutes a day at moderate or vigorous intensity). Participants received feedback regarding their smoking behavior and (non)adherence to the physical activity norm only when they used the application and completed the health risk appraisal component and not during the baseline measurement. Providing this feedback at baseline could have promoted use, as another study found that feedback regarding partial or nonadherence to lifestyle recommendations was positively associated with module use [61]. In contrast to our results, a study by Schneider et al [29] found that individuals with an unhealthy lifestyle were more likely to initiate the program but less likely to complete a module. These earlier studies [29,61] measured module use, while this study measured completion of components. This was inherent in the intervention design, as participants were not steered toward completing a module but were given the option to select components. An explanation for the difference in study results between our study and Schneider et al [29] could be differences in the intervention design. Future research is needed to uncover which design would be best to improve use among individuals with an unhealthy lifestyle.

A third reason for not using the application was experiencing problems logging in to the website. Taking into consideration participants might forget their account information, we provided a personalized link in the prompt emails to access the application without having to log in. The prompt emails containing the personalized link were sent once participants started using the application. This link should also have been embedded in the first invitation to access the website instead of the log-in information so participants never had to log in. However, the invitation email should emphasize that this is their personal account, as never using a password could make it difficult for participants to realize this.

Satisfaction With the Intervention Content

Satisfaction with the intervention content did not have an effect on the primary outcomes of the RCT (ie, smoking cessation and physical activity). Satisfaction was higher among people with a greater intention to change their behavior. Other characteristics did not have a significant influence on satisfaction. In this study, the intervention content was tailored to user's preference [10], and participants were free to choose which intervention components they wanted to complete. Tailoring the use of components to the level of motivation to change their behavior may be helpful for future interventions to increase satisfaction among those with a low intention to change. When dividing satisfaction into different categories, we found that participants rated navigation and comprehensibility the highest. We expected these results, since these aspects were improved during the usability evaluation [24]. Novelty of the tailored feedback scored lowest, but although the information was not new to the participants, it was often still considered to be useful to support healthy living. Reasons for not finding the application useful were not seeing any progress in managing the disease, generally not believing that a computer program could help them, or already maintaining a healthy lifestyle. Yet the qualitative results did not confirm that participants who maintained a healthy lifestyle were less satisfied with the intervention. Even though the feedback was tailored to participant needs, personal relevance scored relatively low. A suggestion was to focus more on comorbidities and rehabilitation therapy, while it was also suggested that a computer could not provide the level of personalization that a health care provider could. Involvement of a health care provider might not only increase satisfaction but also application use [47]. A study by Tabak et al [62] also suggests that the involvement of a health care provider plays an important role in COPD patient adherence to a telehealth intervention, since the modules with low involvement by a health care professional were accessed considerably less often. Another study found similar results: the use of a COPD Web-based self-management platform was higher when the platform was integrated into a disease management approach with trained health care providers encouraging patients to use the platform and when most substantial personal assistance was provided by a research nurse [63]. Our pilot study [26], which included the support of a practice nurse, also showed a considerably higher number of revisits compared to this study. Originally we planned to involve practice nurses in this study; however, due to recruitment problems we could not integrate the application into primary care, which made it unfeasible to involve practice nurses.

Recruitment in the General Practice Setting

This process evaluation confirms that recruiting participants for this study is relatively difficult in a general practice setting. The participation rate and retention rate were significantly lower in the general practice group compared to the online group, despite of extra reminder efforts that had been made in the former group. This is in line with results of other online behavior change intervention studies that included an average of approximately 1 participant per practice in one study [64] and 5 participants per practice in another study [65] compared to approximately 9 participants recruited per practice in this study. These studies also found that recruitment via general practices tends to be less cost effective and yields a lower net effect compared to the Internet, newspaper, and other channels [64,65]. A partial explanation for the relatively positive results in the online group

could be that these individuals had been more motivated to complete questionnaires, since they signed up to be a member of a company for online research and expected to receive research questionnaires for which they received a small reimbursement [66]. Moreover, they all had access to a computer with Internet and received the study invitation through email. It was not possible to invite patients of the general practice group through email, which posed an additional barrier for patients to start the study, as they had to transfer from reading the invitation letter to signing up for the study online.

To address recruitment issues in general practice, a different study design might be helpful. Nagykaldi et al [67] propose a design that involves an implementation phase before the start of the study. During this phase, integration of technology into the delivery of usual care can be accomplished as part of practice improvement, after which a subset of patients can be invited for study participation. This approach might motivate practices and patients to participate, as it focuses on patient health and practice improvement as well as research. Another strategy that could be explored to improve patient recruitment is the use of practice facilitators [68]. Practice facilitators are trained health care professionals, and their main tasks are to assist practices in research and quality improvement projects. Their work includes building long-term relationships with practices, improving communication, and facilitating system-level changes [68]. Practice facilitators can help successfully implement an eHealth intervention in primary care, serving as a resource for practices while aiding the practice level implementation phase of research projects. Sustaining the work of practice facilitators would require structural financial resources. A review of the practice facilitation literature showed that practice facilitators are usually hired by health care authorities, academic medical centers, or through funding from academic research grants [69]. More research is necessary to uncover optimal recruitment strategies of participants in a primary care setting.

Limitations

This study has several limitations. First, participants were mainly recruited through an online panel, which could decrease the external validity of the presented results, as recruitment channel may impact the type of individuals participating in the study. For instance, a study found that recruitment via general practices resulted in a larger proportion of lower educated smokers and COPD patients compared to mass media recruitment [64]. Second, interviewing only participants who used the application might have led to limited information on why participants did not use the application. While reasons for not using the application were revealed by interviewees who used the application minimally, these might differ from participants who did not use the application at all. Third, we did not ask participants what kind of help they would have appreciated from a health care provider and how the application could provide a supporting role when working with a health care provider. This could have provided more insight to which elements of self-management support can be offered effectively by a computer application and when personal support would be needed. Future research should focus on how technology can be effectively integrated into and leveraged in a primary care setting.

Conclusion

This process evaluation revealed several potential causes for the insufficient use of a Web-based COPD self-management application. Although believing that they lived a healthy lifestyle was for certain individuals a reason to not use the program, on a group level lifestyle did not seem to influence application use. Older individuals, those diagnosed with COPD, and those who experienced breathlessness were more likely to revisit the application. To improve application use among younger participants, those at risk for COPD, and those who do not experience breathlessness, we recommend emphasizing the importance of early smoking cessation for health benefit. In addition, we recommend focusing less on COPD and more on general health benefits of changing lifestyle behaviors for the group that is only at risk for COPD. Involvement of a health care professional could improve participant satisfaction with the intervention and may increase engagement with the intervention materials. However, participation and retention rates in the general practice group were low, and online recruitment limits the possibilities of integrating involvement of a health care professional. We suggest that, in order to improve study participant recruitment rates in general practices, technology is integrated into the practice workflow prior to the start of the study and practice facilitators are used to accelerate the implementation process.

Conflicts of Interest

Hein de Vries is scientific director of Vision2Health, a company that licenses evidence-based innovative computer-tailored health communication tools. The other authors declare that they have no competing interests in this work.

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Abbreviations

COPD: chronic obstructive pulmonary disease
IPAQ-SF: International Physical Activity Questionnaire–Short Form
IQR: interquartile range
MET: metabolic equivalent task
MRC: Medical Research Council
RCT: randomized controlled trial
RHSQ: Respiratory Health Screening Questionnaire

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Original Paper

A Novel Patient Engagement Platform Using Accessible Text Messages and Calls (Epharmix): Feasibility Study

Avik Som[1], PhD; Kunjan Patel[2], BA; Eric Sink[2], BS; Robert Mattson Peters[1*], BA; Kavon Javaherian[1*], BA, BSc (Public Health); Jacob Groenendyk[1*], BA; Tonya An[1*], MD; Zhuchen Xu[1*], BS; Gregory M Polites[1*], MD; Melvin Blanchard[1*], MD; Will Ross[3*], MPH, MD

[1]Washington University School of Medicine, St. Louis, MO, United States

[2]Saint Louis University School of Medicine, St. Louis, MO, United States

[3]Department of Internal Medicine, Renal Division, Washington University School of Medicine, St. Louis, MO, United States

[*]these authors contributed equally

Corresponding Author:
Will Ross, MPH, MD
Department of Internal Medicine, Renal Division
Washington University School of Medicine
Box 8023
660 South Euclid Avenue
St. Louis, MO,
United States
Phone: 1 314 362 6861
Fax: 1 314 747 1080
Email: rossw@wustl.edu

Abstract

Background: Patient noncompliance with therapy, treatments, and appointments represents a significant barrier to improving health care delivery and reducing the cost of care. One method to improve therapeutic adherence is to improve feedback loops in getting clinically acute events and issues to the relevant clinical providers as necessary (ranging from detecting hypoglycemic events for patients with diabetes to notifying the provider when patients are out of medications). Patients often don't know which information should prompt a call to their physician and proactive checks by the clinics themselves can be very resource intensive. We hypothesized that a two-way SMS system combined with a platform web service for providers would enable both high patient engagement but also the ability to detect relevant clinical alerts.

Objective: The objectives of this study are to develop a feasible two-way automated SMS/phone call + web service platform for patient-provider communication, and then study the feasibility and acceptability of the Epharmix platform. First, we report utilization rates over the course of the first 18 months of operation including total identified clinically significant events, and second, review results of patient user-satisfaction surveys for interventions for patients with diabetes, COPD, congestive heart failure, hypertension, surgical site infections, and breastfeeding difficulties.

Methods: To test this question, we developed a web service + SMS/phone infrastructure ("Epharmix"). Utilization results were measured based on the total number of text messages or calls sent and received, with percentage engagement defined as a patient responding to a text message at least once in a given week, including the number of clinically significant alerts generated. User satisfaction surveys were sent once per month over the 18 months to measure satisfaction with the system, frequency and degree of communication. Descriptive statistics were used to describe the above information.

Results: In total, 28,386 text messages and 24,017 calls were sent to 929 patients over 9 months. Patients responded to 80% to 90% of messages allowing the system to detect 1164 clinically significant events. Patients reported increased satisfaction and communication with their provider. Epharmix increased the number of patient-provider interactions to over 10 on average in any given month for patients with diabetes, COPD, congestive heart failure, hypertension, surgical site infections, and breastfeeding difficulties.

Conclusions: Engaging high-risk patients remains a difficult process that may be improved through novel, digital health interventions. The Epharmix platform enables increased patient engagement with very low risk to improve clinical outcomes.

We demonstrated that engagement among high-risk populations is possible when health care comes conveniently to where they are.

KEYWORDS

telemedicine; mobile health; eHealth; telehealth; mHealth innovations; bioinformatics; multiple chronic conditions

Introduction

There has been significant interest in the digital health field to use automated and digital health techniques to facilitate scalable, proactive patient outreach. Many attempts have been made using Health Insurance Portability and Accountability Act (HIPAA)-secure application and portal environments to engage patients in their care under encrypted safe harbor provisions as defined by the Health Information Technology for Economic and Clinical Health Act (HITECH) [1-5]. Although these applications may be convenient for some providers and patients, for other patients—particularly those who tend to be nonadherent, high-resource users and Medicaid beneficiaries—application and portal usage can be a significant burden due to lack of Internet access, mobile data costs, downloading mechanics, or time required for implementation [2,6-9].

To do our utmost to help these patients per the provisions of HIPAA, we devised a method that uses widely existing infrastructure to meet patient care needs. Almost all (97%) patients carry a cell phone, and 85% of homeless veterans carry a cell phone [10-12]. All cell phones come with both voice and short message service (SMS) applications preinstalled. All landlines can carry a voice application. Newly developed voice on the cloud technology has allowed us to build an automated software platform that contacts patients en masse with the additional attribute of being toll-free, allowing us to reach low-income patients who may not have minutes or texts available for other purposes. The software platform that our team developed is called Epharmix, and it was implemented at Washington University in St. Louis as a quality improvement initiative.

Although phone calls fall under the safe harbor provisions of the HITECH act, making them automated means that they must meet the requirements put forward by the Federal Communications Commission (FCC) under the Telephone Consumer Protection Act (TCPA) [13-15]. Additionally, due to HIPAA constraints, the content of the messages must be strictly controlled to mitigate the risk of breach of protected health information (PHI) [16,17].

We found that for patients older than 65 years, phone calls were an appropriate and effective means to contact patients. However, for patients under 65 years, text messages are generally seen as a more effective medium for communication. In our system, SMS messages come from toll-free numbers to the patients and on request can be made free to the end user, but SMS messages are intrinsically unencrypted. To mitigate the risk of a reportable breach, we developed a series of measures including scrubbing

messages of all PHI, obtaining informed consent, phone line-specific consenting, and using secure servers.

The Epharmix system possesses several key features to maximize data security and protect patient and provider privacy. Figure 1 describes the organization of data flow in the system. A detailed description of individual disease specific algorithms and interventions can be found on www.epharmix.com. These include building a combination of security measures including infrastructure, identifier removal, clinically relevant surveys, clinical data reporting, voluntary opt-out, toll-free messaging, customizable message frequency, consent confirmation, and time tracking, that are all built into the software. In addition, with our clinical partners we built a process infrastructure including a business associate agreement (BAA), patient consent, and provider workflow. Each of these is described more thoroughly below.

We developed the Epharmix platform with both high availability and patient security in mind. The Epharmix stack was deployed on servers provided by an industry-leading, Health Information Trust Alliance–certified hosting provider. The environment was hardened on the operating system level and included features such as around the clock penetration monitoring, distributed denial of service mitigation, intelligent intellectual property reputation filters, and additional security measures. All data held were placed in file encryption vaults using the AES-256 encryption algorithm; the vaults were managed by a role-based access control system to ensure maximum security. Finally, following log-in, a log-out timer automatically logs the user out of the website after it has been idle for over 30 minutes.

Strict control of the messaging was implemented with all messages pre-vetted and any identifiers removed, ensuring that providers could not send identifying information via either SMS or phone call versions. Messages from patients were restricted to numerical values, single letter, or yes/no answers; no free-form text responses were allowed. This further mitigated the risk of the patient disclosing their own PHI.

Working directly with clinicians, we built a library of 20 disease-specific surveys capable of identifying signs and symptoms across various patient populations. These surveys trigger alerts and reports that providers can review in order to improve clinical management. Providers received alerts via email, text message, page, or phone call when urgent data were ready for their review. These alerts contained no PHI but still relayed the pertinent data necessary to maintain clinical usefulness. Providers were able to access identifiable data by logging in to the secure Web-based portal. Data from the patient regarding patient-reported signs and symptoms can be stored in the Epharmix portal or transferred into the appropriate electronic medical record (EMR). A voluntary opt-out of the

service was built into Epharmix to respond to a patient replying "STOP" or pressing the asterisk on his or her phone. This feature cancels all future messages and ensures compliance with federal communication commission regulations.

Phone calls are initiated from a toll-free number to remove any fees that may otherwise be charged to the patient, whether from a cell phone or a landline. Additionally, a free-to-end-user service makes all SMS text messages free to the end user through the use of an approved short code messaging sequence within the Epharmix software algorithm. For some patients, standard messaging charges may still apply based on their specific mobile plans, but every effort is made to remove these fees.

Message frequency and timing is controlled by the patient initially. In addition, a smart frequency algorithm can modulate the frequency based on the patient's self-reported condition, for instance: when a patient reports values within the provider set thresholds, the message frequency is decreased in order to prevent user fatigue. Likewise, the smart system will also increase message frequency if the clinical thresholds are breached (e.g. fasting blood glucose > 400 mg/dL or >2 events of paroxysmal nocturnal dyspnea or fluid weight gain in heart failure, among others).

To initiate an Epharmix outward message, providers must confirm that they consented the patient. Then, Epharmix confirms the patient's identity and informed consent by asking the first name without including any other identifiers or health information. If a patient does not confirm their acceptance to begin receiving messages, the prescribing provider is notified and the patient is sent no further messages.

Finally, as an added feature, Epharmix tracks all time spent by provider and patient on the phone when using the Epharmix system. The time providers spend managing their patients over the phone can be submitted for reimbursement through newly created chronic care management billing codes. Epharmix creates patient time logs that track the amount of time spent in communication with each patient, which can be used as proof of service when filing for reimbursement.

To implement in the clinic a series of process innovations also needed to be made, including developing a business associate agreement between Epharmix, Inc. and its healthcare implementation sites to allow for data sharing and to define data ownership, as well as defining how patients should consent and how providers would access the data.

Per the implementation site policy, a written authorization form which relayed the risks of unencrypted messaging was required to begin sending SMS messages to patients. For patients not using SMS messages, verbal consent to reach them via automated phone calls was sufficient to begin messages.

Providing reliable and timely reports to providers was a central focus of the Epharmix design. Assistance to providers in viewing their patients' Epharmix data was accomplished through two key methods. The Epharmix software tracks if a provider called their patient or if an alert has already been resolved. For many disease systems, patients are triaged into red, yellow, and green categories based on their self-reported disease severity. For example, patients with diabetes are sorted according to a moving average of their blood glucose values in the past week. This triage system allows providers to focus their calls on the patients in greatest need of their attention at any time.

At 18 months after system implementation, patients using Epharmix demonstrate a 2- to 3-fold increase in response rate compared to general EMR portal usage [18-20]. The results demonstrate a basal weekly response rate of approximately 80% to both text and phone call messages, with up to a 95% response rate depending on the message frequency and particular disease focus. Additionally, Epharmix messages are already being used for the early detection and intervention of clinically significant events such as chronic obstructive pulmonary disease (COPD) exacerbations, heart failure decompensation, and hypoglycemia.

Figure 1. Patient data flow between provider and patient in Epharmix system.

Patient's provider (e.g. care manager or PCP) prescribes Epharmix

EPHARMIX
Patients interact with automated Epharmix messages via phone or text

Medical assistant, nurse, or case/care Manager identifies at-risk patients via emailed reports and reaches out as necessary
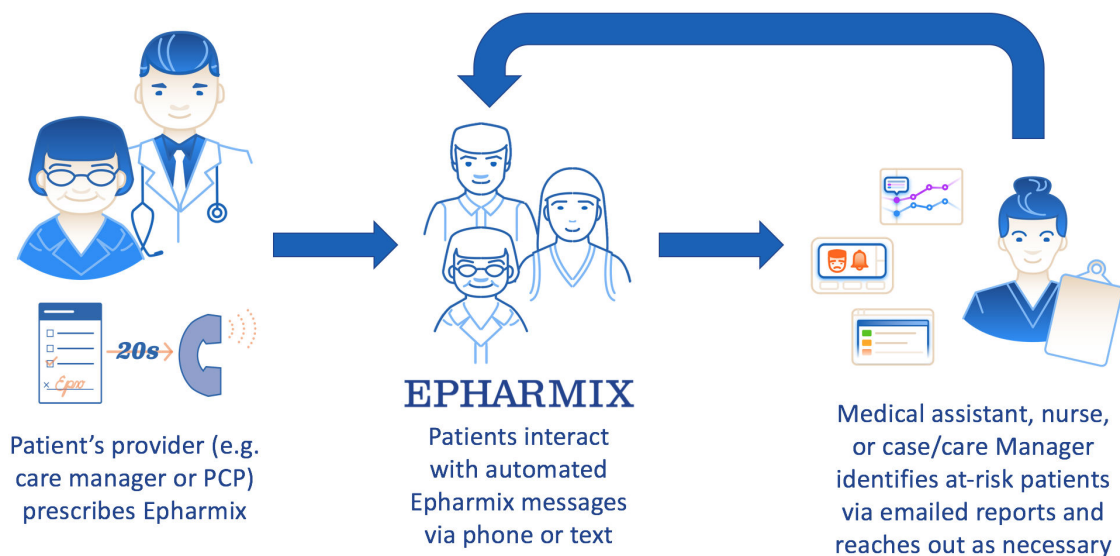
Methods

Overview

Epharmix was developed as an iterative process of design and feedback within the Sling Health (formerly IDEA Labs) innovation incubator at Washington University in St. Louis [21]. A combination of software and process development was used to build a system in compliance with all current healthcare, privacy, and communication regulations. The data reported herein is an aggregate analysis of de-identified data from enrollment in quality improvement projects and randomized controlled trials utilizing the Epharmix system currently underway that was reviewed and approved by the Washington University in St. Louis Institutional Review Board. Three of these studies are currently in press or published [22-26]. Individual analysis of disease specific outcomes and interventions is reported separately. This study reports on the engineering and development of the platform as a whole and its subsequent utilization and feasibility for use in the clinic.

Study Design: Patient Engagement and Satisfaction Analysis

All patients who used Epharmix also received a patient satisfaction survey once per month via text message as part of the implementation. Aggregate deidentified data of the use of Epharmix at Washington University was reported from Epharmix and used in this analysis. No patient specific records were reviewed in this analysis. Because of the aggregate nature of the data across multiple specialties, socioeconomic data could not be collected or analyzed for this particular utilization study. The majority of patients were all adults from St. Louis City and County, and census data for socioeconomic status is reported as a corollary in Table 1 (US Census).

Measures

Number of text messages/phone calls sent and received is defined as the number successfully sent and received from Epharmix. Patients were defined as "not engaged weekly" if they responded 0 times, and they were defined as "engaged weekly" if they responded 1 or more times in a week. The weekly percentage engagement was then the percentage of patients who were "engaged weekly" in any given week as defined above. Similarly, we also calculated the percentage of patients who were engaged monthly by defining "engaged monthly" as responding to 1 or more messages in a month. And then the monthly percentage engagement was then the percentage of patients who were "engaged monthly" in any given week as defined above. Alerts are defined per disease specific intervention and are considered clinically significant if a patient's response is above or below clinically set thresholds, such as a blood glucose > 400. Patient satisfaction with their provider using the service was defined based on a Likert scale from 0-9, with 0 being the worst and 9 being the best. Message frequency was also assessed on a 0 to 9 scale, albeit with 5 being perfect, 0 being too few, and 9 being too many. Finally, patients also report the degree to which the system improved communication with their provider on a 0 to 9 basis where 0 is greatly reduced, 5 is stayed the same, and 9 is greatly improved.

Analysis

Data on engagement and use were analyzed after 18 months of use across a series of disease-specific quality improvement projects and RCTs aimed at improving disease-specific outcomes. Engagement to the Epharmix system reported herein was compared to engagement in the literature seen with health care portals using descriptive statistics.

Table 1. St. Louis city and county residents demographic and income data from which the Epharmix population was recruited (US Census).

Characteristics	St. Louis city	St. Louis county
Age 18-65 years, %	61.2	55.2
Age >65 years, %	11	16.8
Male, %	48.3	47.7
Female, %	51.7	52.3
White, %	43.9	69.5
African American, %	49.2	24.1
Median household income 2011-2015	$35,599	$59,755

Results

Software Development

The user interface of Epharmix inhibits the sending of messages without a confirmation of consent by the patient as noted in Figure 2 below. This checkbox verification feature reduces the risk of messaging without consent and builds in safeguards for compliance with both HIPAA and TCPA.

Using the methods described above, this process has facilitated the completion of 52,403 phone calls (46%) and text messages (54%). Messages do not contain any identifiers, and this mitigates the risk of a text message or phone call releasing PHI to an incorrect person in cases where the phone number entered into the Epharmix system is incorrect. At the same time, text messages and phone calls are easier for patients to use, fitting more into their activities of daily living as compared with more traditional mailers, fliers, or Web-based portals.

Patient Engagement

We find a significant number of engagements, with an average of 13 bidirectional message exchanges with individual patients via text or phone calls per month. Monthly engagement rates have been stable at 80% to 90%, even as the number of patients

on Epharmix has steadily risen (Figure 3). Over the entire course, 14.5% of patients explicitly opted out of usage of the service. Although not directly comparable, these engagement rates may suggest higher patient engagement than that seen in portal usage alone in the literature [19,20].

Satisfaction

We find that these engagements tend to increase overall satisfaction with patients' providers (8.4/9), and patients report an increased degree of communication with their provider (7.3/9). In this survey, a response of 5 referred to the same level of satisfaction or communication, 9 represented more, and less than 5 represented less. A majority of patients felt the frequency of messages was about perfect even as the absolute number of engagements in a year with their provider increased from an average of 3 office visits to about 23 times in a year while using Epharmix (Figure 4).

Clinically Actionable Events

Out of the 52,403 messages sent and received over the course of nine months, there were 1,164 clinically significant events caught, including diabetic hypoglycemia and hyperglycemia, COPD exacerbations, heart failure decompensations, hypertensive crises, wound infections, and breastfeeding complications. These were triggered whenever a patient's responses crossed any of the thresholds as described in Table 2. Once caught by the Epharmix automated system, proactive care was able to be provided as deemed appropriate by the patient's specific provider. Accomplishing this degree of proactive care through an alternative method, such as a provider initiated phone bank, would be cost prohibitive and most likely associated with lower patient engagement [27-29].

Figure 2. In the unauthorized state, Epharmix will not allow a person to receive the automated message. Once authorized, patients may begin receiving Epharmix automated messages.
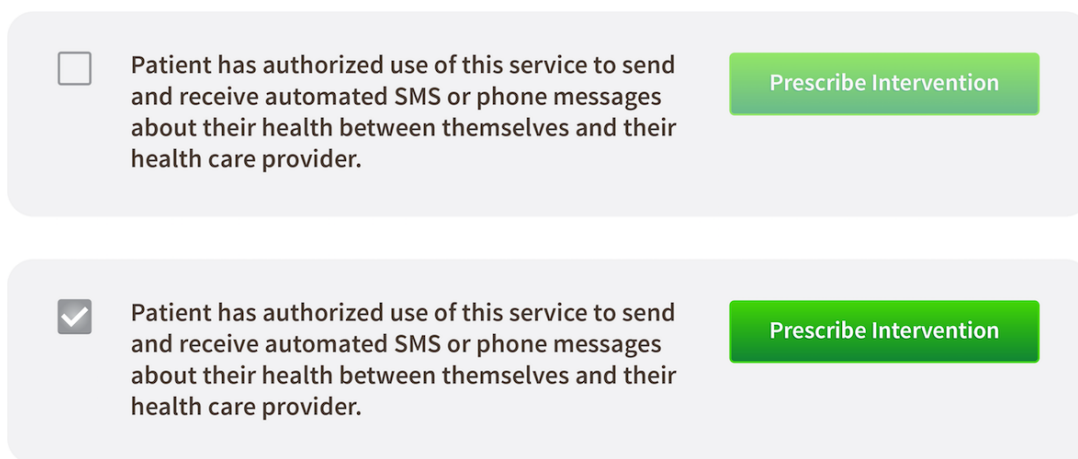
Figure 3. Average number of patient engagements with Epharmix (left) and percentage of patients responding to Epharmix interventions (right).
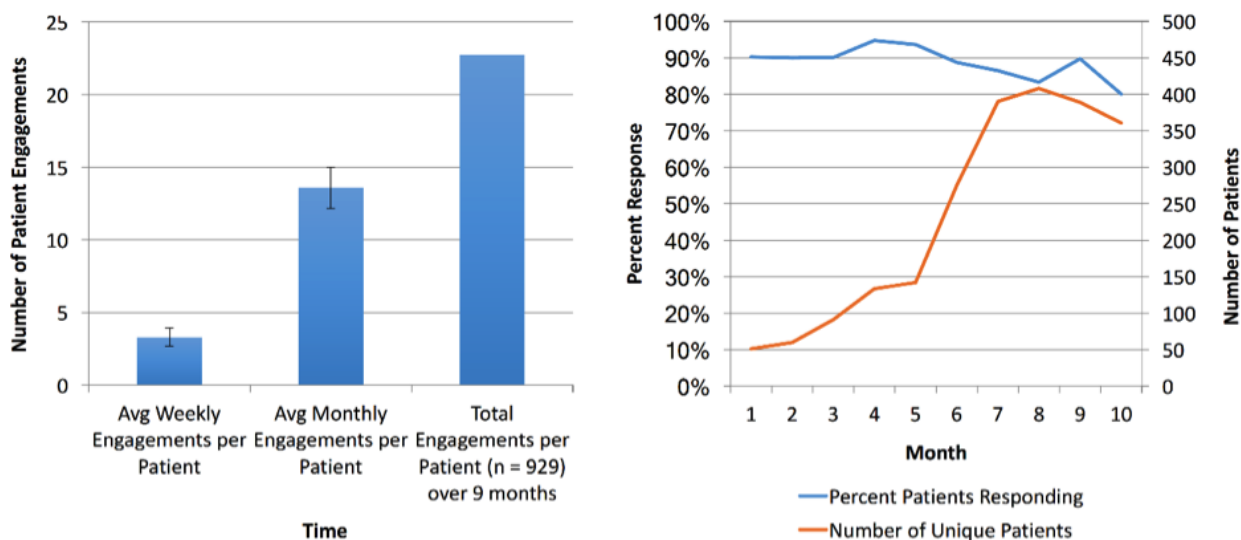
Figure 4. Average patient feedback scores (left) and message frequency feedback ratings (right).
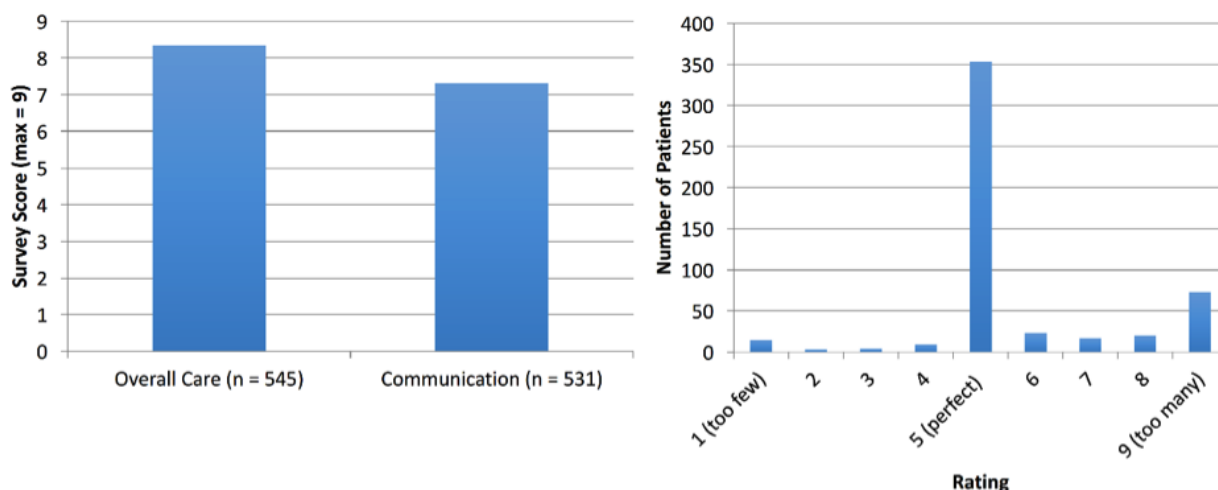
Table 2. Types of clinically significant events identified during the first 18 months of the study.

Intervention	Clinical event
Diabetes	Hypoglycemia (fasting blood glucose <70 mg/dL)
	Hyperglycemia (fasting blood glucose >400 mg/dL)
Chronic obstructive pulmonary disease	Worsening Dyspnea
	Fluid overload: increases in weight (>5 lbs over 1 week as compared to baseline)
Congestive heart failure	Hypertensive crisis (blood pressure >180/110 mm Hg)
	Hypertensive urgency (blood pressure >180/120 mm Hg)
	Tachycardia (heart rate >100 bpm)
	Worsening dyspnea, orthopnea, or pedal edema
Hypertension	Hypertensive crisis (blood pressure >180/110 mm Hg)
	Hypertensive urgency (blood pressure >180/120 mm Hg)
Decolonization	Failure to accept prescribed supplies
Wound	Signs of Infection (worsening pain, drainage, redness, and fever)
Breastfeeding	Patient not exclusively breastfeeding
	Breastfeeding associated (eg, breast pain, difficulty latching, not producing enough milk, insufficient child weight gain)

Discussion

Principal Findings

Building an automated text messaging and phone call system to engage, monitor, and aid patients throughout their care process fundamentally increases engagement. Patients clearly are satisfied with the increased degree of engagement with their providers, and based on our results, find the increased frequency of interactions to be reasonable. The number of clinically significant events identified by this proactive care system emphasizes the utility of distributing accessible electronic messaging systems to patients in traditionally medically underserved areas.

Epharmix provides an example of a solution capable of engaging patients using ubiquitous text messages and phone calls. These lines of communication provide valuable and direct contact approaches, as 80% of cell phone users send and receive text messages [30]. The ability to combine smart algorithmic methods across populations makes this technology much more powerful. Given the high penetration rate of cellphones and landlines among all socioeconomic strata, particularly those with lower incomes, the system enables potentially greater engagement by that otherwise difficult-to-reach patient population.

Limitations

In focusing on developing a system that uses a widespread infrastructure, landlines and cell phones, the system does remain limited in that it does not reach patients who do not have access to landlines or cell phones. Moreover, it does not take advantage of higher end smartphone features such as video conferencing or using Web links. These are possible future features to add to the system as the underlying smartphone technology becomes more standardized, cheaper, and prevalent in older and lower socioeconomic strata.

This study does not determine whether the high engagement correlates to improved clinical outcomes, and we could not correlate the engagement with satisfaction directly because the data is deidentified and all the clinical conditions are aggregated. Because of the aggregate nature of this study we were unable to assess engagement rates by disease states. We are only observing user statistics and so do not know about nonuser health engagement and use, and finally we lack demographic data to make correlations between age and socioeconomic status and engagement. The series of quality improvement projects and RCTs on which this meta-analysis is based will report whether the increased engagement and early detection of clinically significant events associated with Epharmix will improve underlying clinical outcomes.

Conclusions

Using accepted means for mitigating risk, we have been able to create a method using ubiquitous and patient-accessible forms of communication—SMS and phone calls—to improve patient engagement, satisfaction, and the capacity for remote monitoring. We find a significantly increased patient engagement rate that has allowed for the identification of numerous clinically significant events that may otherwise have been missed. The use of this monitoring system allows for the early detection and intervention of clinically significant events within the confines of all compliance requirements. In the context of the literature, great progress has been made in developing 1- and 2-way patient-facing portals, mobile phone apps, and even texting [5,11,20,27]. Developing a two way automated SMS system across multiple disease states is still a challenge for both technical, and security based reasons. The system described enables the use of automated SMS and phone calls to help increase patient engagement feasibly and increase two way feedback loops across multiple disease states. Future directions include analysis per specific disease state and randomized controlled trials to study the impact.

Authors' Contributions

AS, RMP, KP, and ES wrote the manuscript. All authors contributed to the development of the platform infrastructure.

Conflicts of Interest

AS and TA have a financial interest in Epharmix, Inc. All other authors report no conflicts of interest.

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Abbreviations

COPD: chronic obstructive pulmonary disease
EMR: electronic medical record
FCC: Federal Communications Commission
HITECH: Health Information Technology for Economic and Clinical Health Act
HIPAA: Health Insurance Portability and Accountability Act
PHI: protected health information
RCT: randomized controlled trial
SMS: short message service

TCPA: Telephone Consumer Protection Act

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Original Paper

Videoconferencing-Based Treatment of Alcohol Use Disorders: Analyses of Nonparticipation

Kristine Tarp[1], MA, PhD; Anna Mejldal[1], MSc; Anette Søgaard Nielsen[1], MA, PhD

Unit of Clinical Alcohol Research, Department of Clinical Research, University of Southern Denmark, Odense C, Denmark

Corresponding Author:
Kristine Tarp, MA, PhD
Unit of Clinical Alcohol Research
Department of Clinical Research
University of Southern Denmark
J.B. Winsløws Vej 18
Indgang 220B
Odense C, 5000
Denmark
Phone: 45 6550 9359
Email: ktarp@health.sdu.dk

Abstract

Background: We recently conducted a small randomized controlled trial (RCT) aiming to examine the effectiveness of videoconferencing-based treatment of alcohol use disorders in a real-life setting. The patient and participation rates were lower than anticipated.

Objective: The objectives of our study were (1) to examine differences between participants and nonparticipants, and (2) to examine the characteristics of nonparticipants and their reported reasons for not participating.

Methods: First, we analyzed nonparticipation through a comparative analysis of participants and nonparticipants using data from a clinical database, covering all patients starting treatment at the clinic. Second, on the basis of data from an anonymous questionnaire filled out by nonparticipants, we analyzed barriers to participating and the descriptive sociodemographics of nonparticipants who reported technical barriers versus those who did not.

Results: Of 128 consecutive patients starting treatment during the study period, we found no significant differences between participants (n=71) and nonparticipants (n=51) according to sociodemographics, alcohol measures, and composite scores. Of 51 nonparticipants, 43 filled out the questionnaire with reasons for not participating. We derived 2 categories of barriers from the questionnaire: scientific barriers, which were barriers to the scientific study in general (n=6), and technical barriers, which were barriers to using a laptop or videoconferencing specifically (n=27). We found no significant differences in sociodemographics between nonparticipants who reported technical barriers to participating in the study and those who did not note technical barriers. A total of 13 patients elaborated on technical barriers, and 9 patients found videoconferencing impersonal, preferred personal contact, and would rather attend face-to-face treatment at the clinic.

Conclusions: Patient barriers to participating in the RCT were mainly concerned with the technology. There were no significant differences between participants and nonparticipants, nor between nonparticipants who noted technical barriers to participating and those who did not. If a similar study is to be conducted or the solution is to be upscaled and implemented, attention should be given to the user friendliness of the technical equipment and the recruitment process, preparing the patients by emphasizing the information given to them about the technical equipment and its advantages.

KEYWORDS

Introduction

Previous studies on videoconferencing-based treatment of alcohol use disorders (AUDs) have found videoconferencing to be a feasible, acceptable, and increasingly available and used option to deliver treatment of AUDs in real-world settings. Evidence for the equivalence of videoconferencing and face-to-face treatment is fairly consistent with regard to results, reliability, credibility, session attendance, and attrition [1-8]. However, a rather large proportion of patients still decline using technology for treatment sessions and prefer attending treatment face-to-face [6,9].

None of the studies on videoconferencing-based treatment of AUDs performed so far have, to our knowledge, mentioned rates of accepting or declining to participate in the study—that is, the number of patients who refused to participate during the recruitment process. Instead, they all reported different rates of completion, from 50% up to almost 100%. Frueh et al [5] conducted a feasibility study among 18 men receiving videoconferencing-based AUD treatment. They reported that 14 participants completed the study. This was similar to participation rates of other patients in their program, who had a completion rate of about 85% [5]. Kirkwood et al compared videoconferencing-based versus face-to-face AUD treatment and reported that 26 out of 27 participants completed the study [7]. Staton-Tindall et al [1] conducted a randomized controlled trial (RCT) of motivational enhancement therapy delivered via videoconferencing among 75 rural alcohol users on community supervision. They reported that 12 out of 24 randomly assigned participants completed the study [1]. Baca and Manuel conducted an RCT of motivational interviewing via videoconferencing, telephone, and face-to-face among rural problem drinkers. They reported that 29 out of 30 randomly assigned participants completed the first of 2 sessions [3] and a 3-month follow-up rate of 90% [4].

We recently conducted a small RCT (registered with The Regional Committees on Health Research Ethics for Southern Denmark, S-20110052) aimed at examining the effectiveness of videoconferencing-based treatment of AUDs in a real-life setting . Participation was offered to all 128 consecutive patients in the period of recruitment who wished to start AUD treatment at the clinic. However, of these, 51 patients declined to participate. From this situation arose the opportunity and need to examine why these patients declined to participate, as well as their characteristics. We wanted to gain knowledge about whether and how the nonparticipants differed from the participants, and what barriers were at stake when patients declined to participate in the RCT [10].

The objectives of this analysis of nonparticipation were (1) to examine the differences between participants and nonparticipants, and (2) to examine the characteristics of nonparticipants and their reported reasons for not participating. We pursued the objectives through analyses of nonparticipation by (1) a comparative analysis of participants and nonparticipants using data from a clinical database, covering all patients starting treatment at the clinic, and (2) based on data from an anonymous questionnaire filled out by nonparticipants, an analysis of barriers to participating and an analysis of the descriptive sociodemographics of nonparticipants who reported technical barriers versus those who did not.

Methods

Setting

The RCT was carried out in a public outpatient alcohol clinic in Odense, Denmark, between September 2012 and October 2013. At the clinic, AUD treatment is carried out by a multidisciplinary team of social workers, nurses, and psychiatrists. The treatment is conducted according to clinical guidelines [11].

Sampling

Participants (n=71) consisted of patients who agreed to participate in the RCT. Nonparticipants (n=51) consisted of patients who declined to participate (n=47) or later withdrew from the RCT (n=4). Figure 1 shows the overall recruitment process.

Data

Data in this study consisted of self-reported data from 2 sources.

The first source was baseline data from a clinical database on participants and nonparticipants. These data were collected by the therapists at the assessment interview at the start of treatment as a part of the normal routine at the clinic. Data were collected by means of the European version of the Addiction Severity Index (EuropASI) [12,13]. The EuropASI provides data on sociodemographics and alcohol measures and collects data on 9 potential problem areas in the patient's life circumstances: alcohol use, drug use, economic status, employment, legal status, family status, social status, medical status, and psychiatric status. Using EuropASI data, we computed composite scores on the potential problem areas [13]. The composite scores reflect the severity of the 9 potential problem areas during the last month preceding the assessment interview and range from 0 to 1; the higher the score, the greater the severity [12,14]. Studies have demonstrated the Addiction Severity Index (ASI) to be a valid instrument [15,16].

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Figure 1. Flowchart of the recruitment process for the small randomized study.
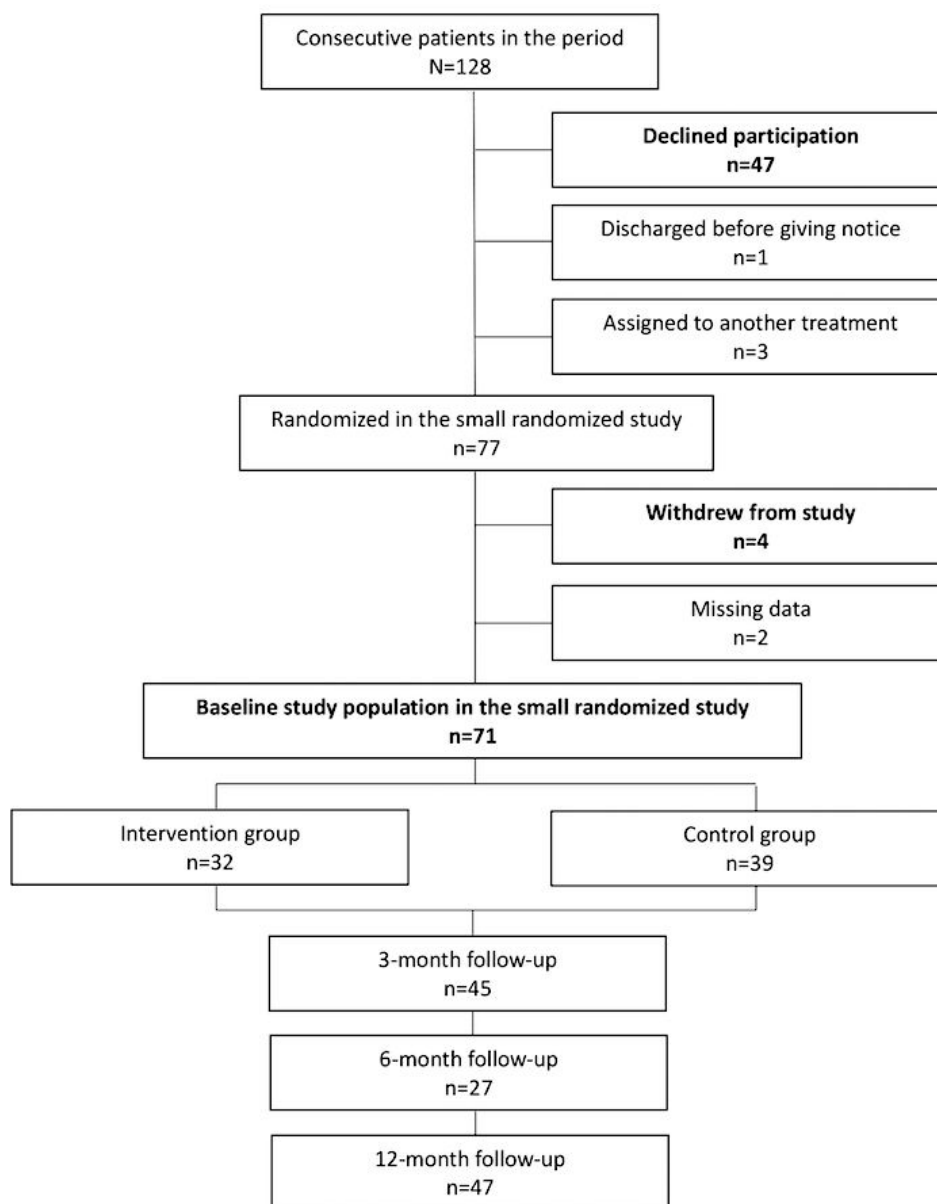
The second source was data from an anonymous questionnaire. We invited all nonparticipants to fill out the questionnaire at the assessment interview. The questionnaire collected information on nonparticipants' sex, age, occupation, and reasons for declining to participate. It was possible for patients to state several reasons for refusing participation. It was also possible for patients to decline giving a reason for not participating. Finally, it was possible for patients to elaborate on their answers. Figure 2 shows the questionnaire.

Statistics

We used Stata v14 (StataCorp LLC) for statistical analyses. To test the relationship between categorical variables, we performed the Pearson chi-square test. If 1 or more of the cells had an expected frequency of 5 or less, we used Fisher exact test. We used the Shapiro-Wilk W test for normal data to check for normally distributed data. To compare the means of a normally distributed interval-dependent variable for 2 independent groups, we performed an independent-samples t test. When we did not assume the dependent variable to be normally distributed, we used the Wilcoxon-Mann-Whitney test.

Figure 2. Questionnaire handed out to patients who declined participation in the study.

The patient declines to participate in the study because:
(It is possible to select multiple reasons)

☐ Decline participation in a research project
☐ Decline participation in the randomization
☐ Decline using video conference
☐ Decline learning how to use the laptop
☐ Decline spending the time learning
☐ Decline one-year-follow-up
☐ Decline giving a reason for declining
☐ Absent from the interview where the patient accepts or declines participation
☐ Other: _____

Sex:
☐ Female
☐ Male

Age: _____

Occupation:
☐ Self-employed
☐ Functionary
☐ Skilled worker
☐ Unskilled worker
☐ Helping spouse
☐ Under education
☐ Stay-at-home
☐ Retired
☐ Unemployed
☐ Early retired
☐ Not working

Results

Participants and Nonparticipants

As Figure 1 shows, we invited 128 patients to participate in the RCT. There were 71 participants and 51 nonparticipants. The nonparticipants consisted of 47 patients who declined to participate and 4 patients who later withdrew from the RCT. Almost all of them had computers of their own, and some of them were accustomed with using videoconferencing.

Table 1 shows the baseline characteristics at treatment start for participants and nonparticipants. We found no significant differences between participants and nonparticipants.

Barriers to Participating

Of the 51 nonparticipants, 43 filled out the questionnaire describing reasons for declining to participate. From the questionnaire, we derived 2 categories of barriers: scientific barriers, consisting of reasons for deciding against participating in a scientific study as such, and technical barriers, consisting of reasons for deciding against using a laptop or videoconferencing in particular. Table 2 shows the distribution of barriers to participating.

Table 1. Baseline characteristics, by participation group (N=128).

Characteristics	Participants (n=71)	Nonparticipants (n=51)	*P* value
EuropASI[a] sociodemographics			
Age in years, mean (SD)	46.7 (12.8)	48.6 (11.2)	.49
Sex (female), % (n)	27 (19)	33 (17)	.43
Higher/continuing[b] education (yes), % (n)	82 (58)	75 (38)	.38
Employed[c] (yes), % (n)	44 (31)	38 (18)	.50
Cohabiting (yes), % (n)	59 (42)	52 (25)	.45
EuropASI alcohol measures			
Age in years at onset of excessive[d] alcohol use, mean (SD)	31.73 (14.14)	33.29 (14.53)	.50
Years of excessive alcohol use in life, mean (SD)	14.85 (11.14)	17.39 (15.92)	.40
Days of alcohol use in past month, mean (SD)	19.34 (10.63)	17.74 (11.60)	.55
Days of excessive alcohol use in past month, mean (SD)	16.76 (10.97)	16.36 (12.01)	.89
EuropASI composite scores[d]			
Alcohol use, mean (SD)	0.70 (0.21)	0.65 (0.23)	.25
Drug use, mean (SD)	0.03 (0.10)	0.02 (0.04)	.89
Economic status, mean (SD)	0.59 (0.45)	0.63 (0.46)	.41
Employment, mean (SD)	0.41 (0.40)	0.45 (0.40)	.58
Legal status, mean (SD)	0.02 (0.10)	0.03 (0.10)	>.99
Family status, mean (SD)	0.17 (0.25)	0.17 (0.25)	.53
Social status, mean (SD)	0.08 (0.18)	0.08 (0.17)	.36
Medical status, mean (SD)	0.29 (0.39)	0.31 (0.41)	.67
Psychiatric status, mean (SD)	0.22 (0.23)	0.22 (0.24)	.96

[a]EuropASI: European version of the Addiction Severity Index.

[b]Some respondents with continuing education attended high school first, some did not.

[c]Not necessarily fulltime.

[d]≥5 units a day in at least 3 days a week during the last 30 days.

[e]EuropASI composite scores vary from 0 (no problem) to 1 (extreme problem) in the 30 days preceding the interview.

Table 2. Categories of barriers to participation derived from questionnaires.

Barriers to participating	No. of replies[a]
Scientific barriers	
Participating in a research project	6
Participating in the randomization	1
Participating in 1-year follow-up	0
Total[b]	7
Technical barriers	
Using videoconferencing	22
Learning how to use the laptop	12
Spending time learning how to use it	13
Total[c]	47

[a]It was possible for the patients to give multiple replies; 4 patients noted both scientific and technical reasons.

[b]Based on replies from 6 patients.

[c]Based on replies from 27 patients.

Table 3. Descriptive sociodemographics of nonparticipants (n=43), according to whether they reported technical barriers.

Characteristics	Technical barriers (n=27)	Nontechnical barriers (n=16)
Age, mean (SD)	49.2 (10.4)	42.5 (14.0)
Sex (female), % (n)	30 (8)	25 (4)
Employed (yes), % (n)	48 (13)	47 (7)

Table 3 shows a descriptive analysis of nonparticipants who had technical barriers to participating, compared with nonparticipants who noted other barriers to participating. No differences were found.

A total of 13 patients elaborated on the technical barriers with regard to using the laptop and videoconferencing, and 9 patients stated that they found it impersonal, preferred personal contact, and would rather attend treatment face-to-face at the clinic. Some of the barriers noted were as follows:

> I think it is nice with a conversation; I want to come here and spend the time this way.

> It is negative for the relation. This is not a medical clinic. I think videoconferencing creates a distance.

> I think the computer will be a visible sign of the treatment. I cannot cope with this.

> I currently live next door to the treatment clinic. I already spend a lot of time at the computer.

> I would like to physically leave the house because I have a depression.

> I have to come for Antabuse anyway.

Discussion

Not wanting to participate in research studies has been reported as becoming more and more common [10], especially when studies are performed over the Internet [17].

Our RCT had a high rate of nonparticipation; hence, attention should be brought to reasons for avoiding participation. This study found that the primary barrier to participating was reluctance to receive treatment sessions via videoconferencing, as nonparticipants reported preferring personal contact. This finding is supported by a qualitative study also nested within the RCT [18]. Similar studies have also found participants to favor face-to-face meetings. Ruskin et al asked 15 participants about their preferences: 10 participants preferred face-to-face, none preferred videoconferencing, and 5 were indifferent [6]. In a qualitative study, Finn et al [9] found that participants preferred a personal meeting and generally had a negative attitude toward receiving treatment via telephone or the Internet in general. These forms were seen as pretreatment interventions to assess alcohol use and receive treatment guidance [9]. Expanding on this, such wishes may, however, be outweighed by the advantages of videoconferencing with regard to, for example, easier access and less stigma. Hence, videoconferencing might seem ideal as a barrier-decreasing option for patients in rural areas, as well as a pretreatment solution for people with a hazardous level of alcohol use who would not seek face-to-face treatment at a clinic because they would feel stigmatized [9,19].

Other studies in alcohol research have found it challenging to recruit and maintain patients for treatment and studies [20]. Thus, ideas for improving participation rates have been suggested, including piloting, building trust, conducting outreach, making repeated attempts to reach out and stay in contact, and using mixed modes of data collection [10]. One approach to enhance participation among similar patient groups resulted in a 90% follow-up participation rate. The approach entails hiring staff to pay special attention to the recruitment and follow-up processes [21,22]. Thus, future studies regarding videoconferencing-based treatment may find inspiration in these ideas and, for example, improve the recruitment process by emphasizing the information given to patients about the technical equipment and its advantages, and thereby preparing patients more thoroughly. In the future, however, barriers may decrease automatically due to general improvement of technical equipment and patients becoming more and more accustomed with using technical equipment, in health care situations as well.

Strengths and Limitations

It is a strength in this study that we were able to obtain some data from nonparticipants at all. When using questionnaires to collect self-reported data, response biases should be considered, since they may have an impact on the validity and reliability of the collected self-reported data [23-27]. However, the use of self-reported data has previously been validated [28,29]. It is also a strength that we used data from different sources, as they may be able to supplement each other. It is a limitation that we were not able to combine the data from nonparticipants concerning reasons for not participating with the data from the clinical database, since the reasons for not participating were given anonymously. Hence, we were not able to describe the 2 groups of nonparticipants (declining to participate for technical versus nontechnical reasons) in more detail. Finally, the small sample size indicates a risk of type 2 error and may have consequences for the inferential conclusions that can be drawn from the results.

Conclusion

Patients' barriers to participating were mainly concerned with the technology; participation was declined because the patients refused to receive treatment via videoconferencing.

There were no significant differences between participants and nonparticipants, nor between nonparticipants who had technical barriers to participating and those who did not; the small numbers preclude conclusions on how the groups differed.

If a similar study is to be conducted or the solution is to be upscaled and implemented, attention should be given to the user friendliness of the technical equipment. Also the recruitment process should prepare patients by emphasizing the information given to them about the technical equipment and its advantages.

Acknowledgments

Conflicts of Interest

None declared.

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Abbreviations

ASI: Addiction Severity Index
AUD: alcohol use disorder
EuropASI: European version of the Addiction Severity Index
RCT: randomized controlled trial

Original Paper

Using mHealth to Support Postabortion Contraceptive Use: Results From a Feasibility Study in Urban Bangladesh

Kamal Kanti Biswas[1], MBA (Health), MBBS; Altaf Hossain[2], PhD; Rezwana Chowdhury[1], MS (Statistics); Kathryn Andersen[3], MS, PhD; Sharmin Sultana[1], MPH, MBBS; S M Shahidullah[1], MPH, MBBS; Erin Pearson[4], MPH, PhD

[1]Ipas Bangladesh, Dhaka, Bangladesh

[2]Bangladesh Association for Prevention of Septic Abortion, Dhaka, Bangladesh

[3]Ipas, Chapel Hill, NC, United States

[4]Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, MA, United States

Corresponding Author:
Kathryn Andersen, MS, PhD
Ipas
P.O. Box 9990
Chapel Hill, NC, 27515
United States
Phone: 919 967 7052
Fax: 919 929 0258
Email: andersenk@Ipas.org

Abstract

Background: As access to mobile technology improves in low- and middle-income countries, it becomes easier to provide information about sensitive issues, such as contraception and abortion. In Bangladesh, 97% of the population has access to a mobile signal, and the equity gap is closing in mobile phone ownership. Bangladesh has a high pregnancy termination rate and improving effective use of contraception after abortion is essential to reducing subsequent unwanted pregnancies.

Objective: This study examines the feasibility and acceptability of implementing a short message service (SMS) text message-based mHealth intervention to support postabortion contraceptive use among abortion clients in Bangladesh, including women's interest in the intervention, intervention preferences, and privacy concerns.

Methods: This feasibility study was conducted in four urban, high abortion caseload facilities. Women enrolled in the study were randomized into an intervention (n=60) or control group (n=60) using block randomization. Women completed a baseline interview on the day of their abortion procedure and a follow-up interview 4 months later (retention rate: 89.1%, 107/120). Women in the intervention group received text message reminders to use their selected postabortion contraceptive methods and reminders to contact the facility if they had problems or concerns with their method. Women who did not select a method received weekly messages that they could visit the clinic if they would like to start a method. Women in the control group did not receive any messages.

Results: Almost all women in the feasibility study reported using their mobile phones at least once per day (98.3%, 118/120) and 77.5% (93/120) used their phones for text messaging. In the intervention group, 87% (48/55) of women were using modern contraception at the 4-month follow-up, whereas 90% (47/52) were using contraception in the control group (*P*=.61). The intervention was not effective in increasing modern contraceptive use at follow-up, but 93% (51/55) of women reported at follow-up that the text reminders helped them use their method correctly and 76% (42/55) said they would sign up for this service again. Approximately half of the participants (53%, 29/55) said that someone they did not want to know about the text message reminders found out, mostly their husbands or children.

Conclusions: In this small-scale feasibility study, text reminders did not increase postabortion contraceptive use. Despite the ineffectiveness of the text reminder intervention, implementation of a mHealth intervention among abortion clients in urban Bangladesh was feasible in that women were interested in receiving follow-up messages after their abortion and mobile phone use was common. Text messages may not be the best modality for a mHealth intervention due to relatively low baseline SMS text message use and privacy concerns.

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Introduction

Mobile technology has potential applications in many aspects of health, and studies have begun to explore how mobile health (mHealth) interventions can be used to support women to use their contraceptive method correctly and consistently to prevent unwanted pregnancy [1]. A recent study in the United States showed that providing complete and accurate information on contraceptives using a mHealth platform can be as effective as in-person counseling, allowing for patients to choose an effective method and helping maximize the use of in-person counseling [2]. A review of studies, mostly conducted in high-income countries, indicates that short message service (SMS) text messaging improves outcomes in antiretroviral therapy and smoking cessation interventions [3]. These studies suggest that SMS text messages may be beneficial as appointment reminders, but not for medication adherence [3]. Yet, studies in several African countries indicate acceptability of contraceptive and medication abortion information via SMS text message [4-6]. A study in rural Uganda testing an intervention with people living with HIV suggests promising results for using SMS text messages to reach rural and low-literacy populations and protecting patient privacy [7]. Nevertheless, a recent review of the utilization of mobile phone technology for improving contraceptive use concluded that there is insufficient evidence for promoting this technology and that the benefits of any intervention greatly depend on the components of the intervention [8]. Further documentation of efforts in a variety of settings, as well as acceptability among different populations, is needed.

The majority of wireless subscribers live in low- and middle-income countries [9]. Bangladesh, like many other low-income countries, has seen an increase in the population's access to mobile technology, with 97% of the population having access to a mobile signal according to the Bangladesh Telecommunications Regulatory Commission [10]. Moreover, a study of household ownership of mobile phones indicates that, once the market was saturated, even households with low socioeconomic levels were able to become mobile owners [10]. As early as 2007, the Ministry of Health and Family Welfare recognized the potential of mHealth and has used mobile technology to broadcast health messages to all cell phone users [9]. Furthermore, a recent study on the impact of electronic media on contraceptive use in Bangladesh shows the promise of digital communication to improve use and continuation of contraceptives [11].

Bangladesh has a high pregnancy termination rate at 37 per 1000 women of reproductive age, compared to the average for South Asia at 26 per 1000 women [12,13]. Improving effective use of contraception after an abortion procedure is essential to reducing subsequent unwanted pregnancies. Abortion service statistics from Bangladesh demonstrate that the most prevalent form of contraception among postabortion clients (>80%) are short-acting methods. Oral contraceptive pills account for the majority of the methods (47%), followed by injectables at 20%

and condoms at 15%. In the general population, there is a high rate of discontinuation among modern contraceptive users. Data from the 2011 Bangladesh Demographic and Health Survey indicate that 47% of condom acceptors, 39% of oral contraceptive pill acceptors, and 36% of injectable acceptors discontinue use within 12 months of initiation [14]. Local beliefs, such as the need to take periodic "breaks" from oral contraceptive pill use [15], may contribute to high discontinuation rates and the high rate of pregnancy termination in Bangladesh. Interventions to support contraceptive continuation are needed, perhaps especially among abortion clients who may have a history of inconsistent contraceptive use.

This study examines the feasibility of implementing a SMS text message-based mHealth intervention among abortion clients in urban Bangladesh to support contraceptive continuation among abortion clients who accept short-acting postabortion contraceptive methods and to promote contraceptive uptake among those who did not select a method. The project used method-specific text message reminders based on the contraceptive method the woman selected on the day of her abortion procedure. We report on mobile phone usage, satisfaction, and privacy concerns associated with the intervention.

Methods

Setting and Participants

This prospective study recruited 120 women from four urban sexual and reproductive health clinics run by the Reproductive Health Services Training and Education Program (RHSTEP) in the divisional capitals of Dhaka, Chittagong, Rajshahi, and Sylhet. Women were eligible for study participation if they received abortion services, selected a short-acting postabortion contraceptive method or no method on the day of their abortion procedure, did not intend to become pregnant in the next four months, did not intend to use their selected method as a temporary method (eg, using condoms temporarily while waiting for sterilization), and had a personal mobile telephone that used Global System for Mobiles (GSM) technology. Participants were randomized into the intervention or control group using computer-generated block randomization. The intervention group (n=60) received the full schedule of method-specific text reminders described subsequently and the control group (n=60) received no reminder messages.

Intervention

Women in the intervention group received method-specific text message reminders to use their selected method (Table 1). The mobile phone number, woman's preferred language, time of day to receive the reminders, and selected contraceptive method (pill, injectable, condom, or none) were entered into a Web-based platform. Data collectors were equipped with netbooks and entered women's data into the system at the time of study enrollment. A test reminder was sent to the woman's

phone after completion of the baseline interview to ensure that the system was working properly and that women knew what to expect. Each message included a study number that participants were instructed to call if they wished to withdraw from the study. The intervention was provided at no cost to women because receiving text messages in Bangladesh is free. All women participating in the study received the standard abortion and postabortion contraceptive care available in the RHSTEP clinics.

Table 1. Schedule and content of text reminders by contraceptive method selected.

Method selected and frequency of messages	Content
Pills	
Daily	Remember to take your medication.
Weekly	Some women experience difficulties with their method. If you are having problems or have any questions about your method, please contact the clinic.
Injectables	
One week before due date of next injection and on injection due date	You can return to the clinic to get your next injection.
Weekly	Some women experience difficulties with their method. If you are having problems or have any questions about your method, please contact the clinic.
Condoms	
Twice weekly	Remember to use your method.
Weekly	Some women experience difficulties with their method. If you are having problems or have any questions about your method, please contact the clinic.
None	
Weekly	You can visit the clinic if you would like to start a method.

Data Collection

Baseline data collection took place from March to June 2013. After obtaining written informed consent, participants completed a 30-minute interviewer-administered survey conducted in Bangla on the day of their abortion procedure. The survey included women's sociodemographic characteristics, fertility intentions, and their frequency of mobile phone usage. All respondents were asked to complete a follow-up survey 4 months after their procedure. Up to three attempts were made to contact each participant to schedule their follow-up interview, and the retention rate was 89.1% (107/120). In the follow-up interview, women in the intervention group were asked about their satisfaction with the intervention and any privacy concerns related to receiving SMS text message reminders. Follow-up data collection occurred from July to October 2013. All data were collected by trained female interviewers from a locally contracted nongovernmental organization, the Bangladesh Association for Prevention of Septic Abortion.

Data Analysis

Completed questionnaires were checked for quality and consistency by research officers and entered into EpiData 3.1 software. The primary outcome of interest was modern contraceptive use at 4-month follow-up, which was assessed for the intervention and control group and compared using a chi-square test. Sociodemographic characteristics of women participating in the study, intervention preferences, and experiences with the SMS text message reminder intervention are presented. Percentages are computed among nonmissing responses. Data were analyzed using Stata/SE 14.0.

Ethical Approval

Institutional Review Board approval was obtained from the Bangladesh Medical Research Council and Allendale Institutional Review Board in the United States.

Intervention Development

A SMS text message system was designed and developed with technical assistance from a local information technology company, Iris Technology Bangladesh. The system used a Web-based platform with secured log-in and delivery to groups of clients depending on their selected postabortion contraceptive method and intervention preferences. Women were able to select their preferred time of day (morning, afternoon, or night) to receive the messages to improve privacy. For example, women could select to have the messages sent during the afternoon if they would be at home alone during that time. Women were also able to select their preferred language for the messages, including Bangla (Unicode), English, or phonetic Bangla in English fonts. The platform supported all GSM phones (used by more than 90% of Bangladesh Telecom subscribers) [16,17], but did not support Code Division Multiple Access phones. The system cost approximately US $2500, including design, customization, and registration. The cost of maintaining the system would be US $192 per year to maintain technical support from Iris Technology and US $0.04 per SMS text message sent.

Results

Characteristics of Study Participants

All 120 women in the sample were married and two-thirds (79/120) had one to two children (Table 2). In all, 85.8%

(103/120) reported having secondary or higher education. Although 70.0% (84/120) of participants reported no financial difficulties, this differed by group assignment with 82% (49/60) of women in the intervention group and only 58% (35/60) of women in the control group reporting no financial problems (*P*=.005). Almost 78.3% (94/120) lived in an urban setting, as

expected given the recruitment sites. A total of 44.1% (53/120) of participants selected pills as their postabortion contraceptive method, although 33.3% (40/120) selected injectables, 20.8% (25/120) selected condoms, and 1.7% (2/120) did not select a postabortion contraceptive method.

Table 2. Sociodemographic profile of study participants (N=120).

Sociodemographic characteristics	Total, n (%) (N=120)	Intervention, n (%) (n=60)	Control, n (%) (n=60)	*P*
Woman's age, mean (SD)	28.1 (5.9)	27.4 (5.8)	28.8 (6.0)	.19
Woman's education, n (%)				.13
None	4 (3.3)	0 (0)	4 (7)	
Primary	13 (10.8)	7 (12)	6 (10)	
Secondary or higher	103 (85.8)	53 (88)	50 (83)	
Husband's age, mean (SD)	35.4 (7.6)	35.1 (7.9)	35.7 (7.4)	.68
Husband's education, n (%)				.44
None	6 (5.0)	2 (3)	4 (7)	
Primary	11 (9.2)	4 (7)	7 (12)	
Secondary or higher	102 (85.0)	53 (90)	49 (81)	
Religion, n (%)				.60
Islam	108 (90.0)	55 (92)	53 (88)	
Hinduism	11 (9.2)	5 (8)	6 (10)	
Buddhism	1 (0.8)	0 (0)	1 (2)	
Marital status, n (%)				
Married	120 (100.0)	60 (100)	60 (100)	
Number of children, n (%)				.17
No children	14 (11.7)	10 (17)	4 (7)	
1-2 children	79 (65.8)	39 (65)	40 (67)	
≥3 children	27 (22.5)	11 (18)	16 (26)	
Financial situation, n (%)				.005
Difficult	36 (29.2)	11 (18)	25 (42)	
Have no problems	84 (70.0)	49 (82)	35 (58)	
Residence, n (%)				.66
Urban	94 (78.3)	48 (80)	46 (77)	
Rural	26 (21.7)	12 (20)	14 (23)	
Postabortion contraceptive selected, n (%)				.59
Pills	53 (44.2)	27 (45)	26 (43)	
Injectables	40 (33.3)	17 (28)	23 (38)	
Condoms	25 (20.8)	15 (25)	10 (17)	
No method	2 (1.7)	1 (2)	1 (2)	

Baseline Mobile Phone Use

Baseline mobile phone use was assessed among all 120 women enrolled in the study. Overall, 98.3% (118/120) of the women enrolled in the study reported using their mobile phone at least once per day. Although 77.5% (93/120) of women used their mobile phones for text messaging, the frequency of use was

low. Approximately one-quarter (23.3%, 28/120) of women reported using text messaging every day, slightly more than one-third (34.2%, 41/120) used text messaging once a week and 20.0% (24/120 women) used text messaging less than once per week.

Baseline Intervention Preferences and Readability of Messages

The majority of women in the intervention group (63%, 38/60) preferred phonetic Bangla in English fonts, primarily because their mobile phones did not support Bangla fonts. In all, 30% (18/60) selected Bangla (Unicode), and 7% (4/60) selected English as the language for their SMS text message reminders. Approximately three-quarters of participants (73%, 44/60) preferred to receive the messages in the evening, 23% (14/60) during the afternoon, and 3% (2/60) in the morning. At the time of study enrollment, a test message was sent to check readability and 93% (56/60) of women were able to read the full message in their selected language. All women were able to read at least part of the message.

Intervention Effectiveness at Follow-Up

Intervention effectiveness was assessed at 4 months postabortion among the 89% (107/120) of women who completed the follow-up interview. Loss to follow-up was differential by education and financial status with poorer and less-educated women more likely to be lost to follow-up. A statistically significant difference in modern contraceptive use 4 months postabortion was not observed between intervention and control groups. In the intervention group, 87% (48/55) of women were using modern contraception at the time of the 4-month follow-up, whereas 90% (47/52) were using a method in the control group ($P=.61$).

Satisfaction With the mHealth Intervention at Follow-Up

Women in the intervention group were asked about their satisfaction with the text reminders at follow-up. Overall, 93% (51/55) of women reported at follow-up that the text reminders helped them use their method correctly. Approximately 87% (48/55) of women said they were satisfied with the timing of the text message reminders and 84% (46/55) said they read the messages regularly. Approximately three-quarters (76%, 42/55) of women said they would sign up for the service again. Women who used their phones for SMS text messages regularly (81%, 13/16) and those who did not use their phones for SMS text messaging at baseline (83%, 10/12) were most likely to say that they would sign up again, whereas women who used their phones for SMS text messaging infrequently were less likely to be interested in signing up again (Figure 1). Among the 24% (13/55) who would not sign up for the service again, approximately half (n=5) said they did not need the reminder, two of the women said their husband did not like the SMS text message service, and one woman expressed privacy concerns.

Figure 1. Interest in signing up for the intervention if offered again by baseline SMS text message use (n=55).
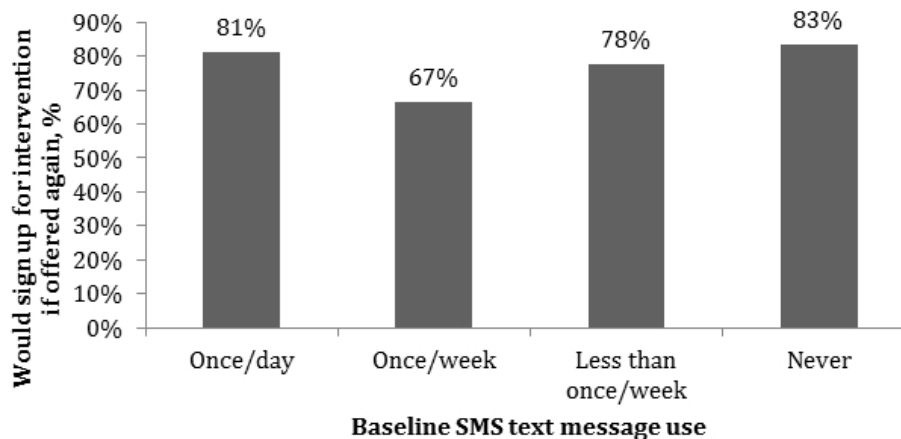

Privacy Concerns

Women were ineligible for study participation if they reported during the consent process that they shared their phone with someone else. Despite this precaution and asking women to select the time of day they wished to receive messages, some women reported challenges with privacy of text messages at follow-up. The majority of participants (93%, 51/55) reported that they were satisfied with the privacy of receiving text message reminders, but approximately half of participants (53%, 29/55) responded affirmatively to the statement "someone I did not want to know about the text reminders found out." For most women (86%, 25/29), it was her husband who found out about the messages, for five women it was her children who found out, for three it was her sister, and for one woman, it was her in-laws who found out. When women were asked further questions about how another person found out, almost half of women who reported that their husbands found out (48%, 12/25) said they showed the message themselves, more than one-third (36%, 9/25) said their husband saw it when it appeared on their phone, and 12% (3/25) reported their husband found it when he checked her phone (Figure 2). For children, 40% (2/5) saw the message as it appeared and 40% (2/5) saw it when they were using her phone. Three women said that they were dissatisfied with the privacy of the text messages, and all three women reported that their children saw the messages and two also reported that their husband saw the messages. Although there were concerns about privacy of the SMS text message reminders, the majority of women reported communicating with their husband about participation in the study (91%, 50/55) and about the contraceptive method they chose after the abortion procedure (96%, 53/55).

Figure 2. Ways in which family members found out about text messages (n=29).
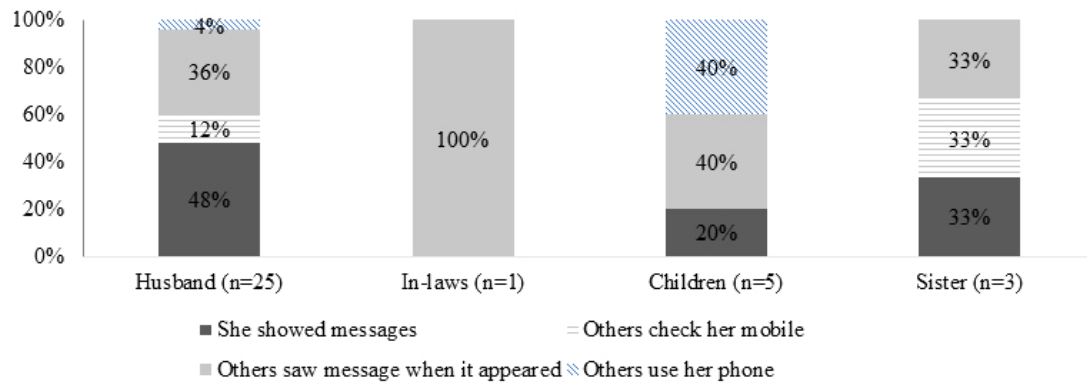
Suggestions for Improving mHealth Intervention

In the follow-up interview, participants were asked to provide suggestions for improving the SMS text message service. Of 27 participants who offered their suggestions, approximately half (14/27) indicated that automated voice messages or phone call reminders would be better for privacy. Two respondents suggested the traditional mode of interpersonal communication through courtyard meetings. One respondent suggested having a number to call to get information. When asked specifically about interest in a hotline for information on abortion and contraception, 96% (53/55) of intervention participants responded that they would be interested in using a hotline. Being able to talk to a counselor was important to some women in the study. Participants were given a mobile phone number enabling them to call the researchers to withdraw from the study if they wanted, but according to call log records, 13% of participants (8/60) called the number with questions on contraceptive methods, although the number was not meant for this purpose. Women were also asked if they would answer questions using mobile text messaging if that incurred a cost. In response, 82% (45/55) of women reported that they would answer text messages if the cost was within the limit of 0.5 to 1.5 Taka (<US $0.01) per message.

Discussion

The simple text reminder intervention did not increase postabortion contraceptive use 4 months postabortion. Despite the ineffectiveness of the text reminder intervention, this study has important findings for those seeking to implement mHealth interventions in the potentially vulnerable population of women receiving abortion services. This study finds that it is feasible to conduct a mHealth intervention with abortion clients in urban Bangladesh because mobile phone use was common and women were interested in receiving follow-up messages after their abortion. However, women also raised privacy concerns associated with text messages appearing on their phones unexpectedly. Reaching out to urban abortion clients through mobile phones could be a feasible strategy, but the best modality should be explored through additional formative work and privacy concerns addressed.

Approximately 93% (51/55) of women reported that the mobile text message helped them use their contraceptive method correctly, but the intervention had no effect on modern contraceptive use at 4 months postabortion. Previous studies have shown that mobile messaging can be a simple and effective means of supporting women's access to sexual and reproductive health information and services [18,19]. However, the evidence for mobile health interventions' effect on actual service utilization is variable, indicating the need for further rigorous analysis on mHealth's contributions to long-term behavior change [8]. It is likely that more interactive and adaptive interventions have a greater impact on behavior change, compared to the simple reminder intervention tested in this study.

There was interest from participants in this study in having a hotline number that they could call with questions (96%, 53/55). Even though a majority of participants reported using text messaging, regular use was low with only 23% (28/120) using their phone for SMS text messaging at least once per day, and verbal communication may be preferred. Interest in signing up for the intervention again varied by SMS text message use at baseline, suggesting that women who already use SMS text messages regularly and those who have little experience with SMS text messages (and may find it novel), might be more interested in receiving SMS text messages than others. A hotline option might be acceptable to a broader group of women and would possibly increase privacy because women could call the hotline at their convenience. Some studies have suggested that interventions using verbal communication increase contraceptive uptake and use [8] and, in Cambodia, using voice messages that link abortion clients with a call center counselor demonstrated increased uptake of long-acting contraceptive methods in the months following abortion [20]. Although the more labor-intensive strategy of employing call center counselors to support women's postabortion contraceptive use appears to be beneficial, the long-term cost-effectiveness is yet to be studied [8]. Additional work is needed to understand whether verbal communication, through automated voice messages or connecting women with a call center counselor, is more acceptable to women.

There were some concerns about privacy related to this intervention, and more work is needed to fully understand women's concerns and preferences. Although 93% (51/55) of women said they were satisfied with the privacy of the SMS text message reminders, approximately half (29/55) reported that someone they did not want to find out about the SMS text message reminders found out. These findings point to the

importance of asking multiple questions related to privacy and not relying only on reports of satisfaction with the privacy that a mHealth intervention affords. When women were further asked how the person found out, most women reported showing the message themselves. The nuanced findings related to self-initiated sharing of text messages may suggest that mHealth interventions could contribute to increased communication about contraception between women and their husbands or partners. Studies have shown that mHealth interventions can lead to improved communication about sexual and reproductive health among partners and to positively influence gender dynamics through increased male cooperation and involvement in health areas that are normally the domain of the woman [21]. However, it is also possible that the women felt obligated to show the message so that no one would be suspicious regarding their communications or were pressured to show the message. The unified theory of acceptance and use of technology provides a useful framework for assessing how characteristics such as gender, age, and social influence impact use of technology. Our findings suggest that in this population, husbands and other family members impact women's use of technology, especially when receiving information on potentially sensitive subjects such as contraception. Women's privacy may be better protected through use of voice calls compared to SMS text messages [18], and future research on similar mHealth interventions should carefully assess how intervention modality can address women's privacy concerns.

Limitations

The feasibility of using the mHealth intervention with abortion clients should be judged within the context of this specific study sample. The study was conducted only in urban areas and findings may not generalize to rural areas of Bangladesh. Further investigation of mobile phone use in rural areas can provide insight into the feasibility of this type of intervention throughout the country. In addition, the small sample size limits power to detect changes in postabortion contraceptive use between baseline and follow-up. Women in the intervention group were wealthier than those in the control group and this baseline imbalance between the two groups could contribute to differences in contraceptive outcomes at follow-up. In addition, poorer and less-educated women were more likely to be lost to follow-up, which could result in an overestimate of postabortion contraceptive use at follow-up. Finally, we lack data on technologic aspects of the intervention, such as the message success rate, and on provider opinions about the intervention, which would have provided more information on the feasibility of conducting a mHealth intervention in this population.

Conclusions

Women's interest and satisfaction with the intervention suggests that a mHealth intervention to support postabortion contraceptive use is feasible in this context, but a more interactive intervention may be required to influence women's postabortion contraceptive outcomes. In addition, SMS may not be the best intervention modality. Abortion clients in urban Bangladesh regularly use their mobile phones, but mobile use for SMS text messages is less common. In addition, lack of privacy of text messages raises concerns, and it may be more acceptable and effective to share information through an intervention that uses a voice messaging system or connects women with a call center counselor to allow for two-way conversation. Additional formative research is needed to customize the modality and content of a mHealth intervention that will be effective in supporting women's postabortion contraceptive use.

Conflicts of Interest

None declared.

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Abbreviations

GSM: Global System for Mobiles
RHSTEP: Reproductive Health Services Training and Education Program
SMS: short message service

Original Paper

Implications for Training on Smartphone Medication Reminder App Use by Adults With Chronic Conditions: Pilot Study Applying the Technology Acceptance Model

Daniel Y Park[1*], MA; Elizabeth M Goering[1*], PhD; Katharine J Head[1*], PhD; Rebecca J Bartlett Ellis[2*], RN, ACNS-BC, PhD

[1]Department of Communication Studies, Indiana University-Purdue University Indianapolis, Indianapolis, IN, United States

[2]Indiana University School of Nursing, Indiana University-Purdue University Indianapolis, Indianapolis, IN, United States

[*]all authors contributed equally

Corresponding Author:
Elizabeth M Goering, PhD
Department of Communication Studies
Indiana University-Purdue University Indianapolis
425 University Boulevard
Indianapolis, IN, 46202
United States
Phone: 1 317 278 3136
Fax: 1 317 278 1025
Email: bgoering@iupui.edu

Abstract

Background: The majority of middle-aged to older patients with chronic conditions report forgetting to take medications as prescribed. The promotion of patients' smartphone medication reminder app (SMRA) use shows promise as a feasible and cost-effective way to support their medication adherence. Providing training on SMRA use, guided by the technology acceptance model (TAM), could be a promising intervention to promote patients' app use.

Objective: The aim of this pilot study was to (1) assess the feasibility of an SMRA training session designed to increase patients' intention to use the app through targeting perceived usefulness of app, perceived ease of app use, and positive subjective norm regarding app use and (2) understand the ways to improve the design and implementation of the training session in a hospital setting.

Methods: A two-group design was employed. A total of 11 patients older than 40 years (median=58, SD=9.55) and taking 3 or more prescribed medications took part in the study on one of two different dates as participants in either the training group (n=5) or nontraining group (n=6). The training group received an approximately 2-hour intervention training session designed to target TAM variables regarding one popular SMRA, the Medisafe app. The nontraining group received an approximately 2-hour control training session where the participants individually explored Medisafe app features. Each training session was concluded with a one-time survey and a one-time focus group.

Results: Mann-Whitney U tests revealed that the level of perceived ease of use (P=.13) and the level of intention to use an SMRA (P=.33) were higher in the training group (median=7.00, median=6.67, respectively) than in the nontraining group (median=6.25, median=5.83). However, the level of perceived usefulness (U=4.50, Z=−1.99, P=.05) and the level of positive subjective norm (P=.25) were lower in the training group (median=6.50, median=4.29) than in the nontraining group (median=6.92, median=4.50). Focus groups revealed the following participants' perceptions of SMRA use in the real-world setting that the intervention training session would need to emphasize in targeting perceived usefulness and positive subjective norm: (1) the participants would find an SMRA to be useful if they thought the app could help address specific struggles in medication adherence in their lives and (2) the participants think that their family members (or health care providers) might view positively the participants' SMRA use in primary care settings (or during routine medical checkups).

Conclusions: Intervention training session, guided by TAM, appeared feasible in targeting patients' perceived ease of use and, thereby, increasing intention to use an SMRA. Emphasizing the real-world utility of SMRA, the training session could better target patients' perceived usefulness and positive subjective norm that are also important in increasing their intention to use the app.

KEYWORDS

chronic disease; education of patients; medication adherence; mHealth; mobile apps; smartphone

Introduction

Background

Approximately 87.5 million middle-aged to older adults in the United States report having one or more chronic conditions [1], and 68% report not taking or filling medications as prescribed [2]. Medication adherence is critical to reducing negative health-related outcomes such as increased hospitalization, morbidity, and mortality [3-5].

Poor medication adherence among middle-aged to older patients with chronic conditions often stems from forgetting [2]. Complex medication schedules for chronic condition management (ie, polypharmacy) [6] might lead these patients to struggle with remembering medication schedules and, thereby, lead them to poorly adhere to medications [7,8].

Smartphone medication reminder apps (SMRAs) that enable users to (1) record prescribed medication information (eg, medication type and dosing schedule) in the app, (2) receive reminders (eg, alarm and message) from the app at the time to take medications, and (3) monitor medication adherence levels via the app [9], show promise as a way to enhance adherence for middle-aged to older patients with chronic conditions. In an experimental setting, a randomized control trial revealed that the patients with a 3-month SMRA use reported higher levels of medication adherence compared with those without app use [9]. In the real-world setting, an SMRA is available to smartphone owners at little to no cost [10], and there is a high rate of smartphone ownership within the middle-aged to older population. For example, 74% of US adults aged between 50 and 64 years report having smartphones [11], which indicates that an SMRA could be utilized with little to no cost by the majority of these adults. In this regard, the promotion of SMRA use among middle-aged to older patients with chronic conditions could be a feasible and cost-effective way to support their medication adherence.

Intervention and the Aims of Pilot Study

Patients' electronic health (eHealth) technology use is likely to be challenged by age-related declines in eHealth literacy [12-14] or ability to incorporate eHealth technology use into health care [15]. As an intervention strategy to promote middle-aged to older adults' eHealth technology use, existing studies have helped these adults to be capable of using the technologies through training sessions [16,17].

In the same vein, providing training on SMRA use shows promise as an intervention strategy to promote middle-aged to older patients' app use. Existing studies have indicated the utility of training sessions (eg, demonstrating SMRA features to patients, having patients complete app-related tasks, and providing patients with app-related education materials) in enabling patients to use an SMRA [9,18,19]. However, little attention has been paid to how to design an SMRA training session to be more effective in promoting the patients' app use, such as which theoretical determinants of app use the training session should focus on to ensure the patients will adopt the use of the app.

The technology acceptance model (TAM) [20,21] provides a useful theoretical framework for informing the design of an SMRA training session, given its focus on the determinants of technology use [20]. Specifically, TAM describes that users' positive perceptions of technology, such as perceived usefulness and perceived ease of use, might lead to intention to use the technology that might, in turn, lead to actual technology use [22]. Furthermore, TAM describes that technology training might lead users to adopt the use of technology when the training first increases users' levels of positive perceptions of technology [22]. Although the more recent unified theory of acceptance and use of technology (UTAUT) [23,24] that TAM is incorporated into also describes technology training (ie, facilitating condition) as the determinant of technology use, the UTAUT describes that the training, independently of users' positive perceptions of technology, might lead users to adopt the use of technology [23,24]. Considering this, when compared with UTAUT, TAM may provide a clearer framework for designing an SMRA training session that aims to ensure the patients' app use by serving as a blueprint for tracking patients' progress from receiving an SMRA training session to increasing the levels of positive perceptions of app to adopting the use of the app.

Among the positive perceptions of technology within TAM, perceived usefulness is defined as the degree to which people think their performance could be improved using a technology [20]. In the case of medication adherence, performance in taking medications as prescribed would be improved using the SMRA. Furthermore, existing studies have shown that perceived usefulness is positively related to intention to use a technology [25-27]. On the basis of this prior research, it is likely that training sessions designed to elicit perceived usefulness would also affect intention to use an SMRA.

Another TAM variable related to positive perceptions, perceived ease of use, is defined as the degree to which people think they can use a technology with little effort [20]. Existing studies have shown that perceived ease of use is positively related to intention to use a technology [28-30], and the research shows that an SMRA training session that affects patients' perceptions of ease at using the app is likely to lead them to use the app.

Figure 1. Technology acceptance model (TAM) framework for a smartphone medication reminder app (SMRA) training session.
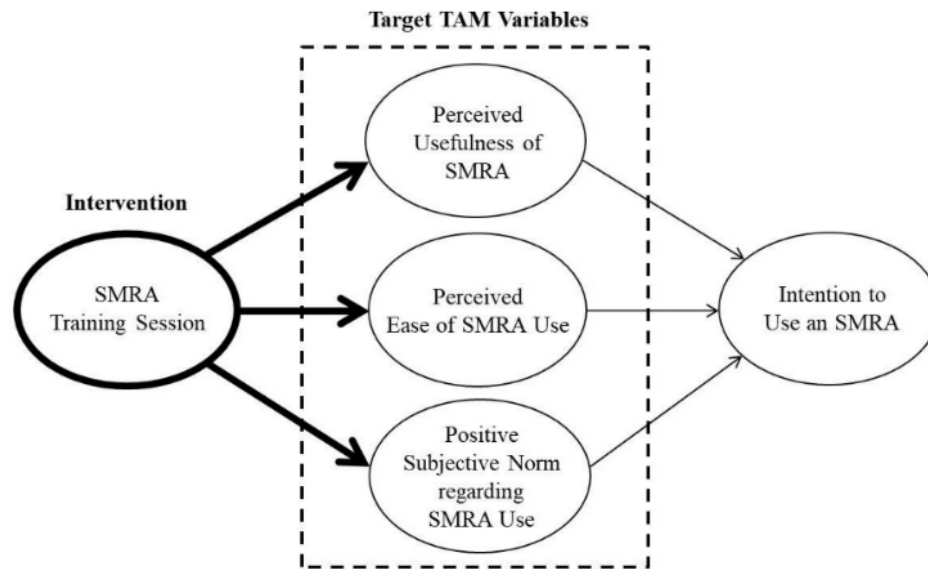
Existing studies [22,25,31,32] have extended TAM by adding subjective norms or people's perceptions of how others would view the subject engaging in specific behaviors [33] such as technology use [22]. These studies have shown that subjective norms are positively related to intention to use a technology, which implies that an SMRA training session that helps patients to think that their family members or health care providers would positively view the patients' app use is likely to lead the patients to use the app. In sum, TAM could be a useful theoretical framework guiding the design of an SMRA training session that aims to ensure the patients' app use focusing on the determinants of app use.

In addition to the guiding theoretical framework for the design of the SMRA training session, addressing how to conduct the training session in ways suitable to middle-aged to older patients is important for an appropriate delivery of the training session. Existing studies have indicated that middle-aged to older adults might feel comfortable learning about new technology when (1) training them in small peer groups in a supportive location, (2) providing them with instructions on technology use on a large screen, and (3) providing them with hands-on experience with technology [16,17,34]. In addition, existing studies have indicated that an SMRA training session of approximately 2 hours might be sufficient to help patients become familiar with app use [9,18]. Following these principles, such as conducting an approximately 2-hour small-group SMRA training session at a hospital, the location that advocates patients' need for health care education [35], and where patients visit for chronic condition management, the training session could be delivered to patients in ways that would help them feel comfortable learning about the app.

The study reported here, guided by TAM, aimed to (1) assess the feasibility of an SMRA training session designed to target patients' perceived usefulness of app, perceived ease of app use, and positive subjective norm regarding app use that might lead to their intention to use the app (Figure 1) and (2) gain insight into how to refine the training session in preparation for a larger main study focusing on these theoretical determinants,

as well as the practical implications of designing and implementing the training session in a hospital setting.

Methods

Pilot Study Design

To meet the first aim of this pilot study, the researchers decided to employ a two-group design with a survey method to (1) have one group receive an SMRA training session designed to target TAM variables (intervention training session) and have another group receive the training session without targeting TAM variables (control training session) and (2) assess the differences in outcome measures (eg, perceived usefulness of SMRA) between the groups [36] so that precisely quantifying whether or not the intervention training session is feasible in targeting TAM variables could be possible [37]. To meet the second aim of the study, the researchers decided to conduct a focus group, which is an appropriate method for exploring shared experiences among a similar group of people [38], to assess why the intervention training session is (or is not) feasible in targeting TAM variables (eg, whether the training session content adequately helped participants perceive the usefulness of SMRA) by exploring participants' communal perceptions of the SMRA in relation to TAM variables at the end of each training session.

Therefore, in this study, one group, as training group, received an intervention training session that was concluded with a one-time survey and a one-time focus group on one of two different study dates. Another group, as nontraining group, received a control training session that was concluded with a one-time survey and a one-time focus group on another date. The details of intervention and control training sessions are described in the following sections.

Development of an SMRA Training Session

The researchers selected the Medisafe app (Figure 2) developed by Medisafe Inc for SMRA training sessions. This app was selected because it is available as a free app for both iPhone operating system (iOS, Apple Inc) and Android devices, making

it cost-effective and accessible to most smartphone users. Additionally, this app has existing evidence of success with middle-aged to older patients with chronic conditions who used the Medisafe app for 6 months, reporting higher levels of medication adherence compared with those without app use [39].

The training sessions for both the training and nontraining groups were developed following the principles deemed suitable for training middle-aged to older patients to use new technologies in general [16,17,34] and SMRA in particular [9,18]. Specifically, the researchers decided to (1) train participants in small groups at their local hospital, (2) use Microsoft PowerPoint slides to provide them with instructions on Medisafe app use, (3) provide them with hands-on experience with the app, and (4) schedule each training session to be approximately 2 hours.

Figure 2. Screenshots of the Medisafe app: virtual pill box (left) and reminder (right) features.
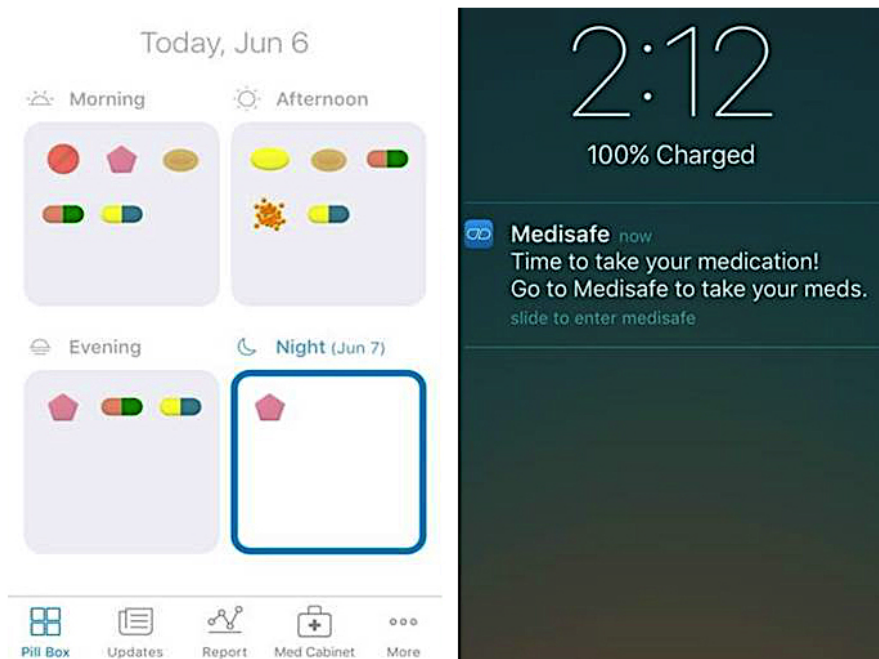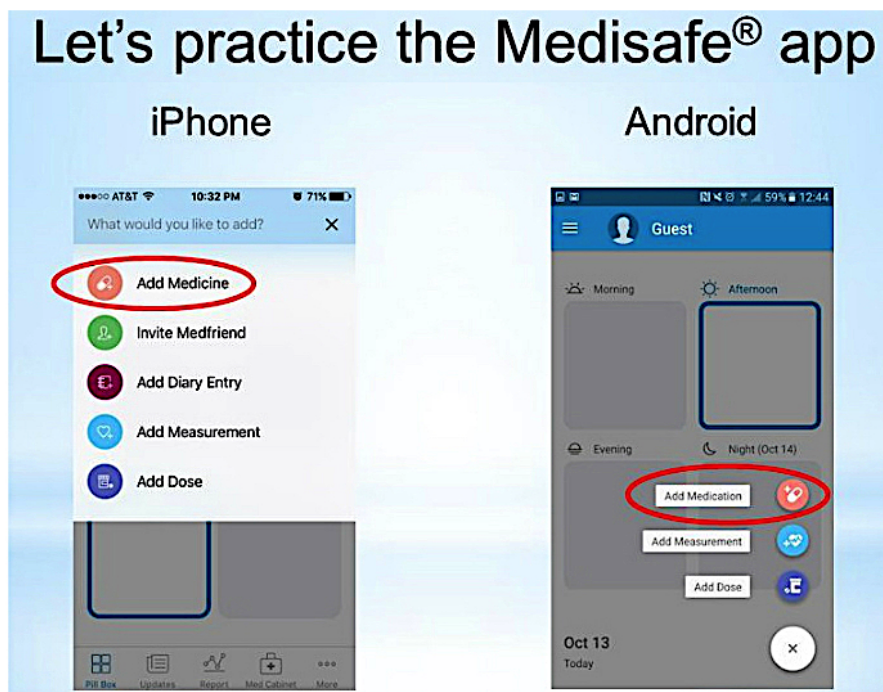

Figure 3. Screenshot of the intervention training session PowerPoint slide.

Regarding intervention training session content for the training group, based on middle-aged to older patients' perceptions and experiences of SMRA use that previous studies have reported [9,18,19], the researchers developed the content to increase participants' levels of perceived usefulness of Medisafe app, perceived ease of app use, and positive subjective norm regarding app use. In addition, as iPhone and Android phones differ in the layout of Medisafe app, the researchers developed the content for iPhone users and for Android phone users separately to prevent participants from being confused by instructions on app use that do not correspond with their smartphone version of app (eg, different location of app feature buttons; Figure 3). Regarding control training session content for the nontraining group, the researchers developed content designed to lead participants to explore Medisafe app features on their own (Table 1).

Sample and Procedures

In fall 2016, this pilot study was conducted at a rural midwestern community hospital after approval was obtained from the university's institutional review board (IRB) and the hospital's IRB. To recruit participants, a designated hospital staff member distributed recruitment materials (ie, study description and contact information to pass on to interested patients) via email to health care providers and staff members throughout the hospital.

Table 1. Descriptions of intervention training session and control training session.

Training session schedule	Training session content and activity
Intervention training session for the training group (up to 2 hours)	
Introduction of SMRA[a] (10 min)	Content: introduction of what an SMRA is in general and what the Medisafe app is in particular (eg, who the developer is, where and at what cost and in which languages the app is available to use)
Targeting TAM[b] variables (20 min)	
Perceived usefulness	Rationale for content: patients reported satisfaction with SMRA that visually (eg, medication pictures) supports correct medication taking [9]; patients described SMRA as useful as it reminds of and helps set up medication routines [19]
	Content: (to increase participants' levels of perceived usefulness of SMRA) introduction of virtual pill box (ie, feature for visually keeping track of medication list) and reminder (ie, feature for being reminded of taking and refilling medications in a timely fashion) features of the Medisafe app
Positive subjective norm	Rationale for content: patients' perceptions of others who support patients' medication adherence matter to patients' continuous SMRA use [19]
	Content: (to increase participants' levels of positive subjective norm regarding SMRA use) introduction of the Medfriend feature (ie, feature for notifying co-app users such as family members if a patient missed a reminder from the app so that they could call or text the patient to additionally remind of medication taking) of the Medisafe app
Perceived ease of use (hands-on experience with SMRA)	Rationale for content: patients often struggled with navigating SMRA features by missing or misinterpreting app feature buttons [18]
	Content: provision of step-by-step instructions on how to use virtual pill box (eg, adding either prescribed or hypothetical medications to the app) and reminder (eg, scheduling reminders and receiving them from the app) features of the Medisafe app
	Activity: (to increase participants' levels of perceived ease of SMRA use) participants practice the above features following step-by-step instructions; participants repeat the practice on their own to ensure their competency in app use
Survey (10 min)	Activity: participants complete a survey measuring TAM variables
Focus group (1 hour)	Activity: participants describe their perceptions of the Medisafe app in relation to TAM variables
Control training session for the nontraining group (up to 2 hours)	
Introduction of SMRA (10 min)	Content: introduction of what an SMRA is in general and what the Medisafe app is in particular
Hands-on experience with SMRA (20 min)	Activity: participants explore any Medisafe app features on their own
Survey (10 min)	Activity: participants complete a survey measuring TAM variables
Focus group (1 hour)	Activity: participants describe their perceptions of the Medisafe app in relation to TAM variables

[a]SMRA: smartphone medication reminder app.

[b]TAM: technology acceptance model.

Eligible participants for the study were patients who had been managing a chronic condition for at least 3 months preceding the study, were taking at least 3 prescribed medications, were aged 40 years or older, use a smartphone, and had no experience of SMRA use. Hospitalized patients, patients with limited English proficiency, and patients unable to travel to the study location during the study period were excluded.

Interested patients contacted 2 researchers (DP and KH) to participate in the study, and 11 participants were recruited as the final sample. The researchers (DP and KH) asked participants to take part in the study on either of two different study dates at their convenience; they were invited to a private room at the hospital on the date they had chosen. One date was for the intervention training session (for training group) and another date was for the control training session (for nontraining group); participants were not informed which date was for the intervention or control training session.

Participants arrived for their group training session, and after obtaining informed consent, the researchers asked participants to download the Medisafe app to their smartphones. After the participants successfully downloaded the Medisafe app to their smartphones, they either participated in the intervention training session (led by researchers DP and EG on one study date) or the control training session (led by researchers DP and KH on another study date). There was no incentive for the completion of training sessions.

Data Collection

Survey

Following the first part of training sessions (hands-on experience with SMRA), the participants completed a survey questionnaire related to demographics and TAM variables (Multimedia Appendix 1). The following TAM variables were measured on a 7-point Likert-type scale ranging from "strongly disagree" (score 1) to "strongly agree" (score 7), and item scores for each variable were summated and averaged to create variable scales (eg, perceived usefulness scale) for data analysis: perceived usefulness (6 items adapted from Davis's [20] study; mean=6.73, median=6.83, SD=0.35), perceived ease of use (6 items adapted from Davis's [20] study; mean=6.05, median=6.33, SD=1.51), subjective norm (7 items adapted from Charng et al's [40] study; mean=4.55, median=4.43, SD=1.17), and intention to use an SMRA (3 items adapted from Venkatesh et al's [23] study; mean=6.03, median=6.00, SD=0.81). Cronbach alpha was calculated to assess an internal consistency of each variable scale, and scores on perceived usefulness (Cronbach alpha=.79), perceived ease of use (Cronbach alpha=.99), subjective norm (Cronbach alpha=.88), and intention to use an SMRA (Cronbach alpha=.97) were deemed acceptable.

Focus Groups

A focus group followed the survey. Participants were asked to describe their perceptions of the SMRA in relation to TAM variables in depth; a semistructured interview guide focused on (1) participants' general struggles related to medication adherence, (2) past strategies to address these struggles, and (3) perceptions about using the SMRA both during the study, as well as how they might use it in their real lives. The focus groups were audio-recorded and then transcribed using a transcription service; after transcription was completed, 2 researchers (DP and EG) checked the accuracy of transcripts. The researchers removed any identifying information from the transcripts and replaced participants' names with pseudonyms.

Data Analysis

Quantitative data was analyzed using SPSS 16.0 (SPSS Inc). As the assumption for normal distribution of the data was unmet (eg, histogram), a Mann-Whitney U test was conducted to assess whether the training group and nontraining group differ in TAM variables.

The transcripts were analyzed using a first- and second-level coding method [38] to identify the themes reflecting participants' perceptions of the SMRA in relation to TAM variables. Two researchers coded the transcripts independently and compared and combined codes. Following the consolidated criteria for reporting qualitative research guidelines [41], the other two researchers reviewed the codes to minimize bias in coding. In addition, the researchers discussed whether and concluded that saturation had been reached.

Results

Participant Characteristics

Of the 11 participants, 45% (5/11) were part of the training group and 55% (6/11) were a part of the nontraining group. All participants were white, and the majority of them were female (73%, 8/11). Participants' ages ranged from 45 to 70 years (median=58, SD=9.55). The majority of participants reported education levels of bachelor's degree or higher (64%, 7/11) and annual household income levels of US $90,000 or greater (73%, 8/11). All but one participant reported they had never used an SMRA before. Chi-square tests and Mann-Whitney U tests revealed that there were no significant differences in demographics between training group and nontraining group (Table 2).

Differences in TAM Variables Between Training Group and Nontraining Group

Mann-Whitney U tests revealed differences in TAM variables between the training group and nontraining group (Table 3). Although there was no significant difference between the groups (P=.33), the training group (median=6.67) reported higher levels of intention to use an SMRA than the nontraining group (median=5.83). In addition, although there was no significant difference between the groups (P=.13), the training group (median=7.00) reported higher levels of perceived ease of use than the nontraining group (median=6.25).

The training group (median=6.50) reported lower levels of perceived usefulness than the nontraining group (median=6.92) at the marginally significant level (U=4.50, Z=−1.99, P=.05). In addition, although there was no significant difference between the groups (P=.25), the training group (median=4.29) reported lower levels of positive subjective norm than the nontraining group (median=4.50).

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Table 2. Demographic profile of the participants.

Demographics	Training group (n=5)	Nontraining group (n=6)	P value[a,b]
Age in years, median (SD)	58 (9.33)	60 (10.57)	>.99[a]
Gender, n (%)			.06[b]
Female	5 (100)	3 (50)	
Male	0 (0)	3 (50)	
Ethnicity, n (%)			.34[b]
Non-Hispanic or Latino	5 (100)	5 (83)	
Unknown	0 (0)	1 (17)	
Race, n (%)			–
White	5 (100)	6 (100)	
Education, n (%)			>.99[a]
Some college, no degree	1 (20)	0 (0)	
Associate degree (eg, occupational)	0 (0)	1 (17)	
Associate degree (academic)	1 (20)	0 (0)	
Bachelor's degree	1 (20)	3 (50)	
Master's degree	1 (20)	1 (17)	
Professional school degree	1 (20)	0 (0)	
Income (USD), n (%)			.76[a]
$70,000-$79,999	0 (0)	1 (17)	
$80,000-$89,999	0 (0)	1 (17)	
$90,000-$99,999	2 (40)	1 (17)	
Greater than $100,000	2 (40)	3 (50)	
Experience of SMRA [c] use, n (%)			.25[b]
Yes	1[d] (20)	0 (0)	
No	4 (80)	6 (100)	
Chronic condition, n (%)			
Acid reflux	0 (0)	1 (17)	.34[b]
Anxiety	0 (0)	1 (17)	.34[b]
Arthritis	2 (40)	4 (67)	.38[b]
Asthma	1 (20)	0 (0)	.25[b]
Back pain	1 (20)	2 (33)	.62[b]
Diabetes	1 (20)	2 (33)	.62[b]
Epilepsy	1 (20)	0 (0)	.29[b]
Heart disease	1 (20)	1 (17)	.89[b]
High blood pressure	2 (40)	4 (67)	.38[b]
High cholesterol	0 (0)	1 (17)	.34[b]
Ulcer or stomach disease	1 (20)	0 (0)	.25[b]
Number of chronic condition, n (%)			.18[a]
1	0 (0)	1 (17)	

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Demographics	Training group (n=5)	Nontraining group (n=6)	*P* value[a,b]
2	5 (100)	1 (17)	
3	0 (0)	3 (50)	
4	0 (0)	1 (17)	
Number of prescribed medication, n (%)			.69[a]
3	2 (40)	2 (33)	
4	1 (20)	0 (0)	
5	1 (20)	1 (17)	
6	1 (20)	0 (0)	
8	0 (0)	1 (17)	
Presence of a caregiver, n (%)			.75[b]
Yes	1 (20)	1 (17)	
No	3 (60)	5 (83)	

[a]*P* values calculated using Mann-Whitney *U* tests.

[b]*P* values calculated using chi-square tests.

[c]SMRA: smartphone medication reminder app.

[d]All participants reported having no experience of SMRA use during the participant recruitment but one of them reported she previously tried and stopped using another SMRA (different from the Medisafe app) during the focus group.

Table 3. Differences in technology acceptance model (TAM) variables between training group and nontraining group.

Variables	Interquartile range	Training group (n=5)		Nontraining group (n=6)		*P* value
		Median	Mean (SD)	Median	Mean (SD)	
Intention to use an SMRA[a]	5.00-7.00	6.67	6.33 (0.85)	5.83	5.78 (0.75)	.33
Perceived usefulness	6.50-7.00	6.50	6.50 (0.42)	6.92	6.92 (0.09)	.05
Perceived ease of use	6.00-7.00	7.00	6.73 (0.43)	6.25	5.47 (1.88)	.13
Positive subjective norm	4.14-5.29	4.29	4.09 (1.34)	4.50	4.93 (0.96)	.25

[a]SMRA: smartphone medication reminder app.

Participants' Perceptions of the SMRA in Relation to TAM Variables

Throughout the focus groups, participants described their perceptions of the SMRA in relation to TAM variables including perceived usefulness, perceived ease of use, positive subjective norm, and intention to use the app.

Perceived Usefulness

Participants described the real-world utility of the SMRA in addressing specific struggles in medication adherence in their lives. Furthermore, participants' intention to use an SMRA was based upon the degree to which their perceived usefulness was positively rated.

Real-World Utility of SMRA in Medication Adherence

Participants described the utility of the SMRA in medication adherence in terms of struggles encountered in the real-world setting. For example, one of participants described her struggle in remembering to take her medications in the evening, saying:

My bedtime one I forget a lot, just because it's, you know, it's later in the evening or whatever and I get busy and I forget that one.

Regarding this struggle, she described the fact that SMRA users would receive reminders from the app as helpful for remembering medication taking, noting:

You always have your phone with you...so, the fact that, you know, it would...vibrate [to remind of medication taking] or do whatever you set it to, I mean, I think that would be very helpful.

Another of the participants described struggles in remembering to take medications when traveling, particularly to places with a different time zone. As Susanna said:

If you're travelling, you know, and you're in [name of place] where the time changes so drastically...Should I take it at, what I would have taken in [name of place] or do I switch it?

Regarding this struggle, she noted that an SMRA feature that reminds of medication taking based on local time would be helpful as she continued:

Then the app would go off [to remind of medication taking].

Yet another participant described her struggle to remember to refill her prescriptions in a timely fashion:

I thought I had some left but I didn't have any left. So then it's like, ok, you gotta call your friends over at the pharmacy, and say, help!

This participant found the Medisafe app feature that reminds users of their medication refilling schedule to be particularly helpful:

The fact that it's gonna remind me is a, is a big help to me, especially when you get 3 months out it's, you know, your mind kind of goes, so.

Some of participants described struggling to manage changing medications. For example, William said:

[I] can identify some of them, but, every few years they change...in the last, 3or 4 months I've, noticed that, there have been a time or two I forgot them.

He went on to acknowledge the potential value of the SMRA in helping him overcome this struggle:

If me and this phone can become friends we might be able to set up where it could remind me pretty good.

In addition, Emily described an SMRA feature that enables recording medications in the app in visually precise ways (ie, virtual pill box) as helpful for managing varying medications, as she said:

I did like how that had, um, the pills you could put the color and the shape...I thought that was nice. Especially because they do change so often.

A final medication adherence struggle participants identified was managing temporary medications. Although participants described using specific tools (eg, Pill box and Outlook calendar) or setting up rules or habits (eg, brushing teeth after medication taking) as ways to support medication adherence, they agreed that managing temporary medications could be particularly challenging. For example, Avery noted:

One of those things that I don't normally take, I'll write right on the bottle...all the dates [for medication taking]...it works but if you have a lot of them it doesn't.

She perceived the potential value of the app as a convenient way to manage temporary medications, noting:

It'd be a lot more convenient to have it set up in there as a temporary, you know, a temporary dosage.

Intention to Use an SMRA

Some of participants described their intention to use an SMRA in relation to perceived usefulness, as William said, when asked if the participants would be willing to use the app in future:

Oh, I think it would be helpful.

More specifically, Grace described her intention to use the reminder feature because it seems helpful for remembering medication taking on weekends when she often ended up second

guessing (eg, "Did I take those before we left the house, I don't remember"). She explained:

Because weekends are hard for me and busy with kids and doing things and so...I think I'll get in the routine of clicking those reminders...it will be a big help.

In sum, the focus groups revealed the utility of SMRA in real-world medication adherence and indicated a potential positive link between perceived usefulness and intention to use the app.

Perceived Ease of Use

The nontraining group described more struggles in SMRA use than the training group. Furthermore, participants' intention to use an SMRA was based upon the degree to which their perceived ease of use was positively rated.

Challenge in SMRA Use by Nontraining Group

The nontraining group, which was given 20 min to explore Medisafe features on their own, described difficulty in using SMRA features that the training group was able to use after 20 min of training that involved step-by-step instruction on app features. Nontraining group participant Emma said:

You can't sit here in 10,15 minutes and understand what's going on with that app.

Michael agreed:

I think I'd need more than 20 minutes to really get a feel for it.

Olivia observed:

I had a little trouble navigating...one of the pills [I recorded in the app] was the wrong shape so I had to go in and change...and it didn't change for me right away.

William said:

I tried to program it [reminder schedule] to 3 a day, but, uh, the milligrams of it [regarding dosing schedule] or whatever, um, never would let me put those in.

In addition, the nontraining group was unaware of SMRA features that were introduced to the training group. Emily said:

I clicked on that [Medfriend feature] but didn't-didn't know what it was so I just got out of it.

Michael observed:

I didn't pay attention to that [virtual pill box].

Nontraining group members also had several unanswered questions for the researchers. Emma, for instance, wanted to know:

What kind of sound does it make when you miss your pill?

Andrew asked:

Can you set the reminders for different days of the week? The times?

Intention to Use an SMRA

Some of participants described that their intention to use an SMRA depends on perceived ease of use, as Avery said:

> Well, [if] it's not easy then I'm not gonna deal with it. Forget it.

In addition, Hannah described that she previously tried another SMRA (different from the Medisafe app) and stopped using it because "it wasn't as user friendly."

In sum, focus groups indicated the challenges in SMRA use by the nontraining group and a potential positive link between perceived ease of use and intention to use the app.

Positive Subjective Norm

Participants described their perceptions of others who might view positively the participants' SMRA use in the real-world setting, such as family members or health care providers. Furthermore, participants' intention to use an SMRA was based upon the degree to which their subjective norm was positively rated.

Family Members and Health Care Providers

Participants described several situations in which they thought others would positively view participants' SMRA use. Some of participants described that doctors could find patients' SMRA use to be positive. For example, Emily explained:

> When you go to a doctor, they want to know, you know, what all medicines are you on. I can never remember...that [SMRA feature helping find medication names] will be a very, very nice feature to have.

Furthermore, some participants described that family members could find patients' SMRA use to be positive. Emily said:

> For loved ones too, if anything ever happens to me, they could take my phone...if I end up in the emergency room...they'll know everything that I take, will be right there on my phone.

In addition, Andrew described that his daughters could find using the Medfriend feature with him to be positive, admitting:

> I think my 2 daughters would appreciate knowing that I'm taking my medication.

Intention to Use an SMRA

Some of participants described their intention to use an SMRA in relation to subjective norm. For example, Grace described her intention to use an SMRA feature that enables recording a medication list in the app because she thought her doctor would perceive it to be helpful. She said:

> I would use it...if I go to an appointment or something, you know, what are you on? I-I can never remember the dosages and things like that so to have it on my phone, it'll be nice.

In contrast, Chloe described her intention to not use the Medfriend feature because others might feel bothered by using the feature with her, as she said:

> No, I don't think I would need anybody to call me because...they would get, uh, tired of saying, hey, take your medicine. I'm gonna take my medicine, I have to take my medicine.

In sum, focus groups indicated specific health care settings (eg, primary care and routine medical checkups) in which the participants think their family members or health care providers would find value in the participants' SMRA use. Furthermore, focus groups indicated a potential positive link between positive subjective norm and intention to use an SMRA.

Discussion

Feasibility of the Intervention Training Session

One of the primary aims of this pilot study was to assess the feasibility of an SMRA training session designed to increase patients' intention to use the app through targeting TAM variables. The findings from this pilot study indicated that the intervention training session was feasible in increasing an intention to use an SMRA through targeting perceived ease of use.

Results revealed that the level of perceived ease of use and the level of intention to use an SMRA were higher in the training group than in the nontraining group, and the focus groups indicated that perceived ease of use might lead to intention to use the app. These findings are consistent with existing studies that have ascertained the path from technology training to perceived ease of use to intention to use the technology [28,42]. In addition, these findings expand existing studies on middle-aged to older patients' SMRA use [9,18,19] by indicating not only the utility of a training session in promoting patients' app use but the type and focus of a training session that could be a promising intervention to promote patients' app use: a scheduled small-group training session in a hospital setting focused on helping patients feel at ease navigating and using the app by providing them with step-by-step instructions on and hands-on experience with app features.

Limitations and Plans for the Future Study

The second aim of this pilot study was to understand how to better design and implement the training session in a hospital setting for the larger main study. There are a couple of limitations of this pilot study that will be addressed in designing the main study.

As the first limitation of this pilot study, the findings indicated that the intervention training session was not feasible in increasing intention to use an SMRA through targeting perceived usefulness and positive subjective norm. Participants indicated in the focus groups that, not surprisingly, the perceived usefulness and positive subjective norm might lead to intention to use an SMRA, consistent with findings from existing TAM literature [22,25,26,28,31,32,43]. However, quantitative results revealed that the level of perceived usefulness and the level of positive subjective norm in the training group did not surpass those in the nontraining group. Understanding the reasons for these findings is important in moving forward to the main study.

First, it may be that the intervention training session did not adequately address perceived usefulness and positive subjective norm, suggesting a need to refine the content of the training session. Beyond the nonsignificant quantitative results related to perceived usefulness and positive subjective norm, the focus group findings may provide some insight. The focus groups revealed that the intervention training session did not include content that would help target perceived usefulness and positive subjective norm.

Regarding perceived usefulness, whereas the intervention training session focused on introducing participants to the technical utility of SMRA in medication adherence (eg, the virtual pill box as a visual aid for correct medication management), throughout the focus groups, the participants described the real-world or practical utility of an SMRA in relation to perceived usefulness. Regarding positive subjective norm, whereas the intervention training session focused on introducing participants to the technical utility of SMRA that enables their family members or health care providers to monitor and support participants' medication adherence (ie, Medfriend feature), many participants described the real-world reasons behind why their family members or health care providers might have positive views on participants' app use in relation to positive subjective norm. In other words, participants indicated that family members or health care providers might view participants' SMRA use more positively because they perceive it to be useful in helping participants stay healthy, both in a day-to-day sense, as well as during an emergency. In sum, it was indicated that introducing participants to the utility of SMRA in medication adherence without applying it to the real-world setting might lead the intervention training session to not adequately target perceived usefulness and positive subjective norm. In this regard, the researchers will plan to refine the content of the intervention training session in ways that (1) emphasize the real-world application of SMRA to addressing patients' specific struggles in medication adherence in their lives (to better target perceived usefulness) and (2) help the patients to see how their family members or health care providers might benefit from the patients' app use (to better target positive subjective norm).

In addition, the intervention training session time allocated to targeting TAM variables (approximately 20 min) might be insufficient to target perceived usefulness and positive subjective norm. For example, within 20 min, the training group participants might feel pressed for time for digesting instructions on SMRA features and might pay more attention to how to use app features than whether and how app features could support them and their family members in (participant) medication adherence in the real-world setting. For this pilot study, the researchers allocated more time to quantitative and qualitative assessments (more than an hour) than targeting TAM variables, given that the primary aims of this study were assessing the feasibility of the intervention training session. For future work, the researchers will plan to increase the time for targeting TAM variables to up to 2 hours, following what the existing studies [9,18] have done (eg, allocating up to 2 hours to the completion of app-related tasks) [18], so that the abovementioned potential

effects of the training session time on the training session outcomes could be mitigated.

The second limitation of this pilot study is associated with sampling issues. Specifically, small sample size (n=11) might result in underpowered and nonsignificant findings (ie, type II errors) [44] and might be insufficient to ensure internal consistencies of variable scales [45]. In addition, a power analysis for the main study was not feasible because of the sample size [45]. Following Hertzog's [45] suggestions for a pilot study sample size for the power analysis, the researchers first planned to recruit at least 20 participants in an attempt to have at least 10 in the training group and 10 in the nontraining group. However, meeting this aim was challenging, and it is attributable to a couple of issues.

Recruitment in a hospital setting may have been more successful except for the time constraints of the hospital staff member who assisted with recruiting (ie, the 2 weeks leading up to the study dates she was unavailable). Addressing time constraint issues with health care professionals is imperative to meet the aims of health care education [35], and the researchers will plan to address this in the future by cooperating with multiple health care providers and staff members, who differ in the time availability of recruitment support, to better meet the aim of participant recruitment for the future study. For health care providers with limited time availability of direct recruitment support, following Lorig's [46] suggestions, the researchers will plan to ask them to (1) permit researchers to place a recruitment poster and sign-up sheet in their waiting room and (2) refer their patients interested in the study to researchers for more information about an SMRA training session.

Furthermore, following what existing studies have done, utilizing more varied recruitment strategies such as (1) placing recruitment flyers in community centers [17,18] or on social media (given the increasing use of social media within the middle-aged to older population) [47], (2) recruiting potential participants at hospital events [24], (3) using the snowball sampling method [48], and (4) using participant incentives (eg, a gift card) [16,18,19] might facilitate meeting the aim of participant recruitment for this pilot study that the researchers will plan to do for the future study.

Utilizing the above recruitment strategies, in addition to increasing participant number, the researchers will plan to increase participant diversity for the future study, given that all participants in this pilot study were white and the majority of them were female and with higher education and income levels. Existing studies have indicated the impact that demographic variables have on patients' medication adherence behaviors [8,49] and might have on their SMRA use. In this regard, recruiting a larger and more diverse sample, the researchers will plan to assess the feasibility of an SMRA training session in targeting TAM variables for patients across demographics.

Conclusions

The findings from this pilot study confirm that an SMRA training session for middle-aged to older patients with chronic conditions is important in promoting their app use. Specifically, the value in designing a TAM-based training session was

indicated, such that the intervention training session appeared feasible in leading patients to adopt the use of an SMRA by first targeting perceived ease of use, guided by TAM. The findings also provide practical implications that will inform the design of the larger main study. Refining intervention training session content (ie, focusing on the utility of an SMRA in the real-world setting) informed by this study and providing patients with sufficient time for digesting instructions on SMRA features,

the training session might better help increase patients' levels of perceived usefulness and positive subjective norm that might also lead them to adopt the use of an SMRA. In addition, cooperating with multiple health care professionals in participant recruitment could help secure a sufficient and continuous recruitment support for meeting the aim of participant recruitment in a hospital setting.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Measurement items for perceived usefulness, perceived ease of use, subjective norm, and intention to use an SMRA.
[PDF File (Adobe PDF File), 17 KB - formative_v1i1e5_app1.pdf]

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Abbreviations

IRB: institutional review board
SMRA: smartphone medication reminder app
TAM: technology acceptance model
UTAUT: unified theory of acceptance and use of technology

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Original Paper

A Health Professional–Led Synchronous Discussion on Facebook: Descriptive Analysis of Users and Activities

Rebecca Grainger[1,2], MBChB, BMedSc, FRACP, PhD; Bonnie White[1], BSc, MSc; Catherine Morton[3], RN, PGDipPH; Karen Day[4], RN, RM, MA, PhD, FACHI

[1]Rehabilitation Research and Teaching Unit, Department of Medicine, University of Otago Wellington, Wellington South, New Zealand

[2]Hutt Hospital, Hutt Valley District Health Board, Lower Hutt, New Zealand

[3]Arthritis Foundation of New Zealand, Wellington, New Zealand

[4]School of Population Health, The University of Auckland, Auckland, New Zealand

Corresponding Author:
Rebecca Grainger, MBChB, BMedSc, FRACP, PhD
Rehabilitation Research and Teaching Unit
Department of Medicine
University of Otago Wellington
23a Mein St
PO Box 7343
Wellington South, 6242
New Zealand
Phone: 64 43855541 ext 4031
Fax: 64 43895725
Email: rebecca.grainger@otago.ac.nz

Abstract

Background: Arthritis is a major cause of pain and disability. Arthritis New Zealand (Arthritis NZ) is a nongovernmental organization that provides advocacy, information, and advice and support services for people with arthritis in New Zealand. Since many people seek health information on the Web, Arthritis NZ has a webpage and a Facebook page. In addition to static content, Arthritis NZ provides synchronous discussions with an arthritis educator each week via Facebook.

Objective: The aim of this study was to describe participation and structure of synchronous discussion with a health educator on a social media platform and the type of information and support provided to people with arthritis during discussions on this social media platform.

Methods: Interpretive multimethods were used. Facebook Analytics were used to describe the users of the Arthritis NZ Facebook page and to provide descriptive summary statistics. Graphic analysis was used to summarize activity during a convenience sample of 10 arthritis educator–led synchronous discussions. Principles of thematic analysis were used to interpret transcripts of all comments from these 10 weekly arthritis educator–led discussions.

Results: Users of the Arthritis NZ Facebook page were predominantly female (1437/1778, 80.82%), aged 18 to 54 years. Three major activities occurred during arthritis educator–led synchronous discussions: (1) seeking or giving support; (2) information enquiry; and (3) information sharing across a broad range of topic areas, largely related to symptoms and maintaining physical functioning. There was limited peer-to-peer interaction, with most threads consisting of two-comment exchanges between the users and arthritis educators.

Conclusions: Arthritis educator–led discussions provided a forum for informational and emotional support for users. The facilitated discussion forum for people with arthritis on Facebook could be enhanced by encouraging increased user participation and increasing peer-to-peer interactions and further training of arthritis educators in facilitation of Web-based discussion. Future research should focus on addressing barriers to user participation and assessing the impact of arthritis educator facilitation training, with the latter leveraging the Action Research paradigm.

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Introduction

People need more than medical diagnosis and intervention to be able to live well while affected by arthritis. Arthritis is the single greatest cause of disability in many parts of the world, affecting 13% to 28% of people, with the burden expected to increase with the aging of developed populations [1]. In the United States, the total financial cost of musculoskeletal diseases, most of which is arthritis, was estimated at US $926 billion in 2011, which was 5.7% of the gross domestic product [2]. Although arthritis is rarely fatal, it has no cure and can affect function and quality of life [3,4], which is reflected in the high indirect financial costs that include loss of employment, informal care, aids, and additional costs when traveling. Difficulties with daily tasks [5] may cause psychological distress for people living with arthritis and their families and carers [6].

In New Zealand, citizens and permanent residents are eligible for free medical treatment in public hospitals, whereas other health services and medicines are subsidized. Primary care physicians (general practitioners [GPs]) are the gatekeepers to medical specialists and surgeons, and people must be referred by their GP to see a specialist. Specialist care usually focuses on medical or surgical management, with less attention on the psychological and functional impacts of arthritis. Appointments are short (usually 15-min long) and clinicians often use medical jargon, and thus people affected by arthritis may end up feeling marginalized, which causes further psychological distress [7-9]. Nongovernmental organizations such as Arthritis New Zealand (Arthritis NZ) provide information, advice, and support services to people with arthritis to supplement medical care [10].

Arthritis NZ's mission is "to improve the lives of people living with arthritis." Its key program areas include advocacy, awareness, information and advice services, research, and support services [11]. The information and advice and support services have traditionally been provided to individuals, groups, and communities by arthritis educators, who are generally nurses or allied health professionals employed by Arthritis NZ, in person and by telephone.

The Internet age has impacted how people seek information and interact with one another about and in response to information they find. Nearly 80% of people in high-income countries access the Internet for more than 1 hour each day [12-14]. Social networking sites are a key activity [12,15]. Since so many people use the Internet to seek health-related information [16,17], many health organizations now have a significant presence on the Web. Support groups meeting the needs of people with long-term health issues, such as diabetes and arthritis, have become popular on Facebook [18]. Social media, in the form of online discussion forums, offer people the opportunities to retrieve, share, and exchange information and experiences, find meaning, and help others [19]. It is flexible in terms of synchronous and asynchronous communication, regardless of geography, time zone, or health system in which participants (active or lurking) usually operate. Informational support, as defined by Cohen and Wills [20], is readily available on the Web but is largely unpredictable and the benefits, risks, and affordances unverified [18,19].

In 2013, Arthritis NZ started a Facebook page for staff and consumers to communicate by leaving posts about topics of interest. A unique feature is the weekly live, synchronous, 2-hour long discussion session led and moderated by an arthritis educator. People join the conversation by clicking on the like button on the Arthritis NZ Facebook page and receive passive updates in their own Facebook newsfeed. They can read postings on the Arthritis NZ page and respond if they wish. The Arthritis NZ Facebook page thereby provides synchronous and asynchronous informational support in the form of an online forum for people affected by arthritis to connect with an arthritis educator and others like them. Similar online communities have been shown to support reciprocal information sharing and facilitate patients moving from simple information gathering to behavioral change [18,19,21]. Although some research has been conducted on the use of asynchronous communication on Facebook for informational support, no research has been done on how synchronous, live, moderated discussions work for supporting people living with arthritis.

The aim of this research project was to conduct an analysis of participants, use, and content of the Arthritis NZ Facebook discussion service to describe the demographics of users of the Arthritis Facebook page and the structure of, and participation in, synchronous discussions with a health educator on the page and the type of information and support people are seeking when participating in these conversations on this social media platform.

Methods

Study Setting and Demographics of the Arthritis NZ Facebook Page Users

Since 2013, a banner on the Arthritis NZ Facebook page stated that every Monday night, between 7:30 PM and 9:30 PM, an arthritis educator would be available to post answers to questions on the Facebook page. Arthritis educators were aware that their role was to provide information and advice, moderate any comments to ensure that the content remained constructive, correct errors in users' posts, and redirect discussions back on topic if the need arose. Arthritis educators had not received any training in communication in social media or online fora. All discussion sessions were run by arthritis educators except for the final session, which was run by the leader of the Arthritis NZ advocacy program.

Data were collected from the Arthritis NZ Facebook page by a member of the research team who was also an employee of Arthritis NZ (CM). A quantitative analysis of the Arthritis NZ Facebook page users was conducted using Facebook Analytics. The data were extracted using the Page Insights function of Facebook on December 7, 2015.

Discussion Participation

All content related to the 10 Monday nights, arthritis educator–led synchronous discussions, between October 12 and December 21, 2015, was copied and pasted into "transcripts" in Microsoft or MS Word documents by CM. Updates and other posts by Arthritis NZ that occurred outside these sessions were excluded. Each transcript replicated the structure of the

discussion thread, including the content, coded names of participants, and frequency and placement of "likes." The data included all posts by page users or arthritis educator on duty during the synchronous discussion session (short updates, questions, and comments), comments (in response to a post by anyone), and likes. Page activity data were summarized using counts and descriptive statistics, including the number of participants, the number of posts (comments), conversations (a post on a new topic with no reference to previous posts with the subsequent posts directly in reply to the new topic), replies (a comment replying directly to a previous post or comment), the frequency of contributions by participants, and who conversed with whom about what. The open-source Gephi computer program [22] was used to describe the network of active users (people who had commented on the Arthritis NZ Facebook page). A simple diagrammatic analysis of 2 discussions was also constructed.

Discussion Thread Content

The data were analyzed by reading the transcripts repeatedly, identifying codes that clustered into themes, and reviewing and naming the themes [23-25]. Each transcript of qualitative data was printed, cut, and coded, and then manually grouped by theme, for example, information seeking. Transcripts were kept as MS Word documents and imported into an MS Excel file for detailed coding and analysis. Each transcript was analyzed as a sequence of comments (ie, as it appeared in the Arthritis NZ Facebook page). Memos were written about the codes to enhance the analysis. KD coded the first 2 transcripts to set up the basic parameters of the analysis. BW then coded all the transcripts, adding details for the codes. Once all the transcripts were coded, RG independently coded 2 weeks' randomly selected transcripts. Where uncertainty or differences in coding occurred, a discussion was held to achieve convergence. The coding aligned for all 3 researchers by the end of the analysis.

Ethical Considerations

This study was designed in collaboration with the Arthritis NZ management team, principally the Senior Advisor of Clinical Services and Research (CM). Ethical approval was obtained through the University of Otago Human Ethics Committee (OUHEC (Health) D15/316). The Chief Executive of Arthritis

NZ provided written informed consent on behalf of Arthritis NZ, and all arthritis educators also provided written consent for participation. Arthritis educators were able to opt out of participation with no consequence from their employer. A pinned post was displayed at the top of the Facebook page throughout the study period, informing viewers that page activities were being collected and anonymized for research. A link to the full participant information sheet and opt-out mechanisms was provided. An Arthritis NZ employee (CM) collected the data, anonymized it for analysis purposes and to protect the identity of the Facebook page users, and sent it to the researchers for analysis. The discussion threads have been deleted in Facebook to avoid participants from being identified. The pinned post and participant information sheet are available in Multimedia Appendix 1.

Results

Demographics of the Arthritis NZ Facebook Page Users

On October 12, 2015 (start of study period), the Arthritis NZ Facebook page indicated that 1778 people had clicked the like icon and were therefore users of the page. As on December 7, 2015, the majority were females (80.82%) who were in the age group of 25 to 54 years (Table 1). In a 4-week period within the study period (November 7 to December 7, 2015), only 22.05% (392/1778) of users clicked on any aspect of the Facebook page, and 8.38% (149/1778) actively participated on the page (ie, posted to the timeline, commented or shared a page post, or responded to a posting).

Discussion Participation

Arthritis educator–led discussion threads were relatively small, with a median of 7 users (excluding arthritis educator) posting (range 2-27) a median of 5.5 conversations (range 1-24) and a median of 25.5 posts (range 10-77) (Table 2). Arthritis educator–led sessions for weeks 1 to 9 of the study were of similar size, with a median of 22 comments and 7 users. The final arthritis educator session was facilitated by the leader of the Arthritis NZ advocacy program rather than an arthritis educator and was larger with 27 users contributing 77 comments.

Table 1. Demographics of likers of Arthritis New Zealand Facebook page.

Age in years	Users n (%)	Female n (%)	Male n (%)
13-17	19 (1.06)	15 (0.85)	4 (0.23)
18-24	160 (8.99)	124 (6.97)	36 (2.02)
25-34	391 (21.99)	320 (17.99)	71 (3.99)
35-44	427 (24.01)	356 (20.02)	71 (3.99)
45-54	373 (20.97)	302 (16.98)	71 (3.99)
55-64	249 (14.00)	213 (11.98)	36 (2.02)
65+	125 (7.03)	107 (6.01)	18 (1.01)
Total	1778 (100)	1437 (80.82)[a]	307 (17.27)[a]

[a]34 users did not state gender.

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Table 2. Quantitative descriptors of all arthritis educator discussion sessions.

Quantitative descriptors	Number of active participants (including arthritis educators)	Number of conversations	Number of comments
Mean	8.6	7.4	29.5
Median	7	5.5	25.5
Range	2-27	1-24	10-77
Total	55	74	295

This may be because the Arthritis NZ advocacy leader asked for comments on areas that users wished for advocacy with government agencies or the health system. Furthermore, 14 users replied to other users during this final session, whereas 11 users had replied to others during weeks 1 to 9 combined.

Arthritis educator comments accounted for 44.1% (130/295) of all comments over the 10-week study period. Excluding arthritis educators, most users commented infrequently. In total, there were 55 individuals who posted in discussion threads: 60% (33/55) posted in only 1 conversation, 25% (14/55) posted in 2 conversations, 9% (5/55) posted in 3 conversations, 4% (2/55) posted in 4 conversations, and 2% (1/55) posted in 5 conversations. The 10 users who commented most frequently contributed 48.1% (142/295) of all comments. Most comments were new conversations, with only 28.1% (83/295) of comments being in reply to another user's comment.

The network diagram generated by Gephi did not reveal a meaningful analysis other than that one person (possibly arthritis educator) contributed to the bulk of the postings and most participants responded to those posts rather than to one another, with a few people responding to one another. Two weeks' transcripts were selected and manually analyzed, as depicted in Figure 1, because they represent different forms of conversation (one with many participants and one with few). The darker the lines between participants, the more comments attributed to their interaction. An arthritis educator always opened the discussion with an invitation and closed the session with a closing comment. The arthritis educator responded to topic initiators, and, in many instances, a combination of interactions between the initiator and arthritis educator ensued with some participants contributing sometimes. This pattern where an arthritis educator dominated the conversation was apparent in the transcripts of all arthritis educator–led discussion sessions.

More people participated in week 2 (n=13) than week 6 (n=4), when the interaction was predictably simpler. In both weeks, the arthritis educator directed most postings to "all," and people initiated topics to "all." There were 3 conversations that did not appear to involve "all" in week 2 and none in week 6. Furthermore, it appears that when a participant posts a comment to "all," responses are directed to specific people. For example, in week 6, MB posted a question about shin splints and a conversation consisting of 4 comments ensued between MB and the arthritis educator.

Discussion Thread Content

Three themes were identified in the content of the comments. The major theme was seeking and giving support, through sharing of experiences (from other users), or information (usually from arthritis educators). Two smaller themes of information inquiry and information sharing were also identified.

Theme 1: Seeking and Giving Support

Comments seeking support included expressions of negative impacts of arthritis regarding symptoms, emotional well-being, daily function, and participation. Users' comments indicated how the diagnosis of arthritis often invoked fear, uncertainty, and isolation, as described below:

> It's terrifying for me I got told I have psoriatic arthritis and handed some steroid meds [sic] and a pamphlet on methotrexate which they told me to go on it's a scary, scary sounding medication.

They felt they were on their own and perceived a lack of emotional support from the health system. They expressed frustration and dissatisfaction with health care services.

Figure 1. Manual network analysis of two discussion threads.

Week 2

Week 6
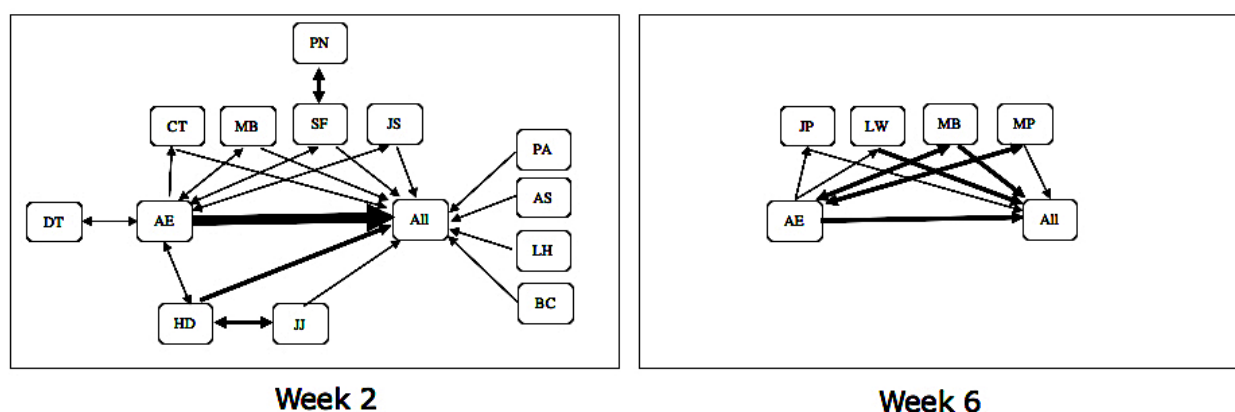
Suboptimal symptom control, particularly pain, impacted on emotional well-being, with one participant commenting:

> ...sometimes it's hard to stay positive when even getting pain relief is an issue.

Comments on impaired function and social participation referenced the social construct of disability [26]. For example, use of crutches or wheelchairs and limited parking space restricted access to public spaces. Some participants described how workplaces may not be supportive of people with arthritis, which could have an impact on work participation:

> Many workplaces/managers think it's just too hard to employ someone with a chronic disease and say it's a performance issue when they take sick leave.

Although public hospital specialist services are free at the point of care in New Zealand, a combination of financial difficulties and appointment waiting times was a common barrier to health care service access. One participant asked for help with shin splint treatment, saying that she "can't afford to buy expensive runners…" Another participant said:

> My doc [GP] referred me to the public hospital but they don't want to know. I do have [insurance] but as I am a single working mum finding the extra 20% is just unobtainable...

Several participants commented about their perceptions about their doctors' knowledge and lack of emotional support. One of the participants said:

> ...my doc doesn't seem to care.

Another participant observed that her doctor's focus was "usually diagnosis, drugs, and off you go" when she felt a need for her doctor to provide support group information.

Support was given by (1) the Arthritis NZ arthritis educators and (2) sought from participants by others, in arthritis educator–led discussions on Facebook. Arthritis educators offered emotional support with positive feedback and endorsed constructive lifestyle changes. Informational support included advice about nonpharmacological management options, strategies for coping and promoting emotional well-being, and suggestions about the most appropriate health care professionals for specific concerns. This quote below from an arthritis educator is representative of the type and depth of informational advice provided:

> Fatigue is such a common symptom, even when you are not in a "flair" [sic] period of RA. It is certainly worth investigating to see if there is any underlying reason like anaemia. However pacing, regular moderate exercise, and dedicated time for relaxation may help. Low energy is one of the possible side effects of methotrexate. There are other hints about fatigue that might help, one of the educators could have a chat if you want to give us a call.

Participants acknowledged informational support from Arthritis NZ but expressed a need for more emotional support. They also expressed a preference for peer-to-peer emotional support, which could occur on the Web. In contrast to their expressed desire, direct participant-to-participant expressions of emotional support

were infrequent, as can be seen in the interaction pattern in Figure 1. A participant indicated that Arthritis NZ provides good informational support and that she looks to other online groups for emotional support:

> I've found online groups way better in terms of support so google [sic] them and make contact.

Theme 2: Information Inquiry

Participants requested information for four key reasons. The first reason was to obtain information to contextualize their symptoms and/or comorbidities in relation to arthritis or its treatments, and they were looking for explanations of what they were experiencing. For example, "Is arthritis worse in cold weather?" One person wanted to know about the relationship between inflammation and "a burning in the knee" and another had no pain issues but was on treatment for "wicked acid attacks" and was looking for ways to augment the medication already being taken.

The second reason for information inquiry was to find solutions to mitigate functional impairments (eg, access in and out of cars, walking shoes, and packaging). One participant wanted to do some walking and was looking for a recommendation on "good men's shoes that are supportive for arthritis that is causing inflammation in the Achilles."

The third reason for information inquiry was to understand the usefulness or implementation of lifestyle changes such as diet, improving sleep quality, and benefits or harm from complementary or alternative therapies.

Finally, they sought knowledge to optimize their experience and understanding of medical care, including recommendations for knowledgeable or sympathetic doctors. They asked for information about medication use, including side effects of arthritis-specific medications (eg, methotrexate and biologic disease modifying antirheumatic drugs) and the utility of deferring medication recommended by their rheumatologist until their personally assessed need exceeds their perceptions of harm, as expressed below:

> I have not been taking any meds and do as much as I can but recently one knee has been giving me lots of grief with aching, locking and feeling very swollen...I guess my question is what sorts of meds should I look into to help me? I haven't wanted to start on meds until really needed.

Theme 3: Information Sharing

Shared information included triggers for symptoms and experiences of symptom management strategies. Arthritis educator offered most information, often detailing scientific rationales for treatments and providing external links to Web-based information. Almost half of the comments by arthritis educators offering information (18 out of 45 comments) recommended consultation with a doctor, and 8 out of 45 comments recommended consulting another health professional (including physiotherapist, dietician, pharmacist, nurse, and podiatrist). These comments are recognizing the limitations of their own professional boundaries and the online environment. When participants offered solutions to others, more conversation

was stimulated. Solutions offered included nonpharmacological treatment (eg, exercise, weight loss), advice to consider surgery, and alternative approaches to completing activities of daily living. One participant described her exploration of yoga, saying:

> *Did my first yoga class last week was a bit worried whether my RA joints and body would cope but it was brilliant. The graceful stretching and meditation was amazing but it certainly made me realise how tight my body gets from holding pain all the time. Really think yoga might be my thing for helping me relax and destressing.*

Discussion

Principal Findings and Comparison With Prior Work

The Arthritis NZ Facebook likers were predominantly younger women. This is consistent with other data showing that women seek health information on the Web more often than men, are more likely to use social media and blogging for health reasons, and have a lower dropout rate in Web-based, self-help interventions compared with men [13,27-29].

Arthritis educator–led synchronous discussions were small, with a median of 8 participants. Only 5% of the likers of the Arthritis NZ Facebook page posted comments during the 10 discussions, with 10 users contributing half of all comments. A similar public question-and-answer session on Facebook for medication use questions also reports low number of active comments with a mean of 5 questions per hour; however, extensive shares and likes resulted in a mean reach of 3776 per week, suggesting the information was useful to a much larger number of people [30]. These observations are consistent with other Web-based behavior; less than 20% of people who read other people's health experiences actually posted health-related comments themselves [31]. Those who lurked probably benefited from reading information in online support groups, but sharing information in online support groups is more effective in enhancing mental and social well-being [32,33].

The key activity identified in arthritis educator–led discussions was seeking or giving support, the majority of which was informational support although instances of emotional support occurred. Content analysis of Facebook groups for diabetes [18,34] and dialysis [35] has shown information sharing and emotional support as the predominant activities on these pages. These Facebook groups were not moderated or supported by a health organization, and therefore, also contained promotion of non–FDA (Food and Drug Administration)-approved treatments [18], and health advice was provided by peers rather than health professionals [18,34,35]. The analysis of the synchronous arthritis educator–led discussions confirmed that a synchronous discussion on a social media platform can be used to provide health information relevant to an individual's requirements, as previously observed [27]. Furthermore, arthritis educators, who also recognized limitations of providing information on the Web without context, recommended individuals to seek advice from doctors in 18 out of 45 comments, thus arthritis educators were behaving professionally and recognizing clinical scope of practice.

The content focus of discussion threads included symptoms, function, medication concerns, and the wider health care system. It is hypothesized that social media may be preferred for sharing minor concerns rather than serious symptoms or personal information [36]. This is likely because of the lack of anonymity of online social networks such as Facebook as all information is linked to a personal account. Nevertheless, sharing even minor concerns is likely to be of value to users of arthritis educator–led discussions as online social support groups have been identified as an important source of comradeship through sharing similar experiences [37]. Furthermore, participation in online communities for medical conditions can foster a sense of well-being and control and increase self-confidence and independence [37,38]. The content analysis identified multiple areas of health needs for the small number of people who did comment.

While the majority of interactions in arthritis educator–led discussions were between participants and arthritis educators, there was some peer-to-peer interaction. The online environment has potential for peer-to-peer support, including helping others understand medical science and care [39] and empowering others to find supportive and knowledgeable doctors [40,41]. Internet support groups have been suggested as able to mitigate the negative effects of time-pressured medical practice [39]. While peer-to-peer interaction may have benefits, within the context of this discussion facilitated by an arthritis educator of Arthritis NZ, the key drivers for the interactions are the program objectives of Arthritis NZ, in particular information and advice services.

Limitations

The key limitations of this descriptive study include change in behavior as a result of being observed (Hawthorn effect) and the generalizability of the results. To collect data ethically, all users of the Arthritis NZ Facebook page were notified of the data collection before and during the study period, and posting comments implied consent. Arthritis educators and participants may have changed their posting behavior or/and users may have chosen not to post during the study period, introducing bias. Furthermore, the passive data collection and interpretation may not have accurately captured the participants' intended meaning of their comment. In addition, when arthritis educator comments provided information, it is not possible to ascertain whether the information met the participants' requirements.

The proportion of page followers who posted or commented during the 10 arthritis educator–led discussions in the study period was very low (5%) and most participants who did comment, did so infrequently. This study cannot infer anything about what benefit individuals may gain by reading arthritis educator–led discussions without posting.

Conclusions

This study shows that a moderated discussion forum for people with arthritis can provide information and support to people affected by arthritis. An online information and advice service can be available to people who are unable or do not wish to attend face-to-face services or do attend formal health care services but have unmet or ongoing needs for information and

support. Such an online forum could also be used to inform people of advances in treatments or available support services. The detailed and specific information that was requested by users does suggest that informational needs were not being met within formal health care settings and that behavior in online environments can provide insight into unmet health needs.

Users of online health forums could have the ability to connect with each other to exchange information and support, although this did not happen frequently in the current setting. Specific training for arthritis educators in posting behavior that engages users in discussion and facilitates peer-to-peer interaction could be encouraged. More active discussion may also occur in a less accessible discussion space, for example, a closed Facebook group, where the moderator of the group authorizes entry to the group and only users can view the comments. Furthermore, using people with arthritis as moderators may encourage active participation from more users or generate a richer discussion by bridging the space between laypersons and providers of health information. If these techniques encouraged more peer-to-peer interaction, a greater sense of community and comradeship for people affected by arthritis could be generated. Future research should focus on addressing barriers to user participation and assessing the impact of arthritis educator facilitation training, with the latter leveraging the Action Research paradigm.

Acknowledgments

Authors' Contributions

All authors contributed to the primary data collection and analysis, the drafting and review of the manuscript, and approved the final version of the manuscript.

Conflicts of Interest

RG is a nominated member of the Governing Body of Arthritis New Zealand, representing the New Zealand Rheumatology Association. CM is an employee of Arthritis New Zealand.

Multimedia Appendix 1

Participant information available via Arthritis New Zealand Facebook page.

[PDF File (Adobe PDF File), 431KB - formative_v1i1e6_app1.pdf]

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Abbreviations

Arthritis NZ: Arthritis New Zealand
FDA: Food and Drug Administration
GPs: general practitioners

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Original Paper

Identifying Asbestos-Containing Materials in Homes: Design and Development of the ACM Check Mobile Phone App

Matthew Hayden Govorko[1], MPH; Lin Fritschi[1], PhD; James White[2], PhD; Alison Reid[1], PhD

[1]School of Public Health, Curtin University, Perth, Australia
[2]Reach Health Promotion Innovations, Perth, Australia

Corresponding Author:
Alison Reid, PhD
School of Public Health
Curtin University
GPO Box U1987, Bentley
Perth, 6845
Australia
Phone: 61 8 9266 1361
Fax: 61 8 9266 2958
Email: alison.reid@curtin.edu.au

Abstract

Background: Asbestos-containing materials (ACMs) can still be found in many homes in Australia and other countries. ACMs present a health risk when they are damaged or disturbed, such as during do-it-yourself home renovations. However, community members lack knowledge and awareness about asbestos identification and its safe management in residential settings.

Objective: The objective of our study was to describe the process of developing a mobile phone app, ACM Check, that incorporates a questionnaire designed to identify and assess ACMs located in residential settings.

Methods: A multidisciplinary team was involved in the formative development and creation of the mobile phone app. The formative development process comprised 6 steps: defining the scope of the app; conducting a comprehensive desktop review by searching online literature databases, as well as a wider online search for gray literature; drafting and revising the content, questionnaire, conditional branching rules, and scoring algorithms; obtaining expert input; manually pretesting the questionnaire; and formulating a final content document to be provided to the software development company. We then constructed ACM Check on the iOS platform for use in a validation study, and then updated the app, replicated it on Android, and released it to the public.

Results: The ACM Check app identifies potential ACMs, prioritizes the materials based on their condition and likelihood of disturbance, and generates a summary report for each house assessed.

Conclusions: ACM Check is an initiative to raise community members' awareness of asbestos in the residential environment and also serves as a data collection tool for epidemiologic research. It can potentially be modified for implementation in other countries or used as the basis for the assessment of other occupational or environmental hazards.

Introduction

Asbestos is the term given to a family of naturally occurring fibrous silicates that have been used in a wide variety of building materials, commonly referred to as asbestos-containing materials (ACMs) [1]. Australia was the highest per capita consumer of ACMs in the world during the mid-20th century [2]. Many of these ACMs were asbestos cement products, such as flat and corrugated asbestos cement sheeting, in which the asbestos fibers were bonded to a base material. These products were installed in residential settings between the mid-1940s and the late 1980s [3]. Until the 1960s, approximately 25% of all new Australian homes were clad with asbestos cement products [2], and it is likely that almost all houses built before 1990 contain some form of asbestos [3]. All forms of asbestos have been classified as carcinogenic [4], and a prohibition was declared

on all new uses of asbestos in Australia in 2004. However, the prohibition does not extend to ACMs that were in place prior to the date the prohibition was enforced [5]. As a result, a large amount of asbestos is still present in the residential environment.

However, identifying ACMs is difficult, and householders lack knowledge and awareness regarding the identification of ACMs in and around the home and how to safely manage these materials to prevent exposure to asbestos fibers [6]. Identifying in situ ACMs is complicated by the large and varied uses of asbestos prior to its phase out. This is exacerbated by the similarities in visual features between certain older ACMs and the newer asbestos-free materials, which makes distinguishing between ACMs and non-ACMs complicated for the untrained individual. An Australian asbestos awareness survey conducted in 2014 found that participants' confidence in their ability to identify ACMs was low, particularly among do-it-yourself (DIY) home renovators and the general public [6]. The survey established that greater practical information and guidance were needed on how to identify ACMs and how to correctly manage the risks [6].

ACMs present a health risk when they are in poor condition due to damage, deterioration, or weathering, or when they are disturbed. For instance, a significant number of asbestos fibers can be released into the air when working with asbestos cement sheeting in houses, eaves, fences, or sheds, especially when using power tools for cutting, drilling, grinding, sanding, or sawing [7,8]. This may particularly be a problem for DIY home renovators if they do not take appropriate precautions when dealing with potential ACMs.

In Australia, smartphones are owned by approximately 80% of people over the age of 18 years, with the majority of the market being held by Apple (41%) and Samsung (32%) [9]. Because asbestos identification requires close-up visual inspection of the features of various types of materials that are spread throughout different locations around the property, their high level of portability makes smartphones and tablets an ideal platform to administer an app targeting asbestos identification. Mobile apps have been developed and used to target other environmental health issues, such as air quality [10], noise monitoring [11], and sun safety and melanoma prevention [12,13]. However, no mobile apps are freely available in Australia that can be used to screen the residential property for the presence of in situ asbestos. Therefore, household occupants need to turn to an environmental consultant, asbestos inspector, industrial hygienist, or other qualified professional, which can be costly to the home owner. Similar to mobile apps that can be used as early-stage screening tools such as for prostate cancer [14] or depression [15], a mobile app that screens for asbestos can be a tool that empowers users to approach the issue and take the first step toward prevention, action, or remediation.

The aim of this paper is to describe the design and development of the mobile app ACM Check (short for Asbestos-Containing Material Check). ACM Check is an initiative to raise community members' awareness of asbestos in the home environment and also serves as a data collection tool for epidemiologic research.

Methods

The development of ACM Check was approved by the Human Research Ethics Committee (RDHS-89-15) of Curtin University, Perth, Australia.

The Multidisciplinary Research and Development Team

We developed ACM Check in a collaborative partnership involving occupational epidemiologists and a doctoral student in public health and epidemiology from the School of Public Health, Curtin University; scientific health officers and toxicologists from a state environmental health agency (Environmental Health Directorate, Western Australia Department of Health, Perth); and a health promotion software development company (Reach HPI, Perth). Following advice from previous health promotion-based and researcher-led app development projects [16-18], we involved the software developer early on in the process due to the need for specialized development skills when developing native mobile apps (versus other communication technologies, such as text messaging or websites). We engaged the software development company to provide guidance surrounding the technical aspects of mobile app development and to bring expertise in the field of graphic design, user interface design, and user experience design.

Development Process

The development of the app was an iterative process that occurred in 2 broad phases: formative development, followed by creation of the mobile app. The formative development process comprised the following steps: planning and defining the scope of the app; conducting a comprehensive desktop review; drafting and revising the content, questionnaire, conditional branching rules, and scoring algorithms; obtaining expert consultation and input; manually pretesting the questionnaire; and formulating a final content document, which was provided to the software development company.

Phase 1: Formative Development

In the first stage of the formative development process, we defined the scope and aim of the app. We clarified the target end users, the rationale for development, the functions we wanted to include, the data outputs we wanted to generate, and how these aims would be achieved (Table 1).

We undertook a comprehensive desktop review of scientific peer-reviewed journal articles obtained from online databases, including PubMed, ProQuest, and ScienceDirect, and gray literature obtained from Australian government and nongovernment websites, such as the Asbestos Safety and Eradication Agency and state health department websites, prior to drafting the content for the app. We also reviewed the reference lists of the publications for additional relevant literature. Search terms were "asbestos" OR "asbestos-containing materials" AND "identification," "survey," "questionnaire," "assessment," "material assessment," "exposure assessment," "risk assessment," and "condition assessment." Documents published by the Australian federal and state government health authorities were the primary basis of the background information used in the app.

Table 1. Scope of ACM Check.

Key Factor	Parameters of ACM Check
Problem	Difficulties visually identifying ACMs[a] in residential settings
	Lack of awareness among DIY[b] renovators
Target audience	Householders, particularly DIY renovators
	Local government environmental health officers
	Tradespeople working in the residential sector
Setting	Residential settings in Western Australia, which excludes commercial, industrial, and waste sites
Objectives	Identify in situ ACMs inside and outside homes
	Assess current condition and likelihood of disturbing the ACMs
	Direct users to further resources that assist in the safe management of asbestos
	Collect questionnaire data regarding the amount, type, and condition of ACMs
Method	Conduct a self-administered questionnaire using automated conditional branching (if-then rules) and an additive scoring algorithm for priority assessment
	Generate a summary report for each completed home inspection
	Provide links to relevant information, resources, and contacts
Significance	Increase users' awareness of asbestos in the residential environment
	Inform relevant government and nongovernment agencies about the current amount and condition of ACMs in Western Australian households

[a]ACM: asbestos-containing material.

[b]DIY: do-it-yourself.

We also searched for examples of different ways to assess the condition and exposure potential of ACMs in residential or occupational settings. We held meetings with the development team to help define the scope of the app and determine what areas or materials are likely to be of most significance in the community. We sought input from 9 further experts and stakeholders outside of the development team after we had made some revisions of the content and questionnaire, including local government environmental health officers, environmental consultants, and asbestos removalists.

We pretested the questionnaire using pen and paper to test the practicality of the questions and instructions, to test the flow of the conditional branching (if-then rules), and to assess the scoring algorithms. The outputs, such as probabilities of each key material containing asbestos and its overall rating, were calculated manually at the completion of each trial. The pretesting also provided approximations for the time it would take to complete the inspection and questionnaire once it was in the digital format. We revised and finalized the questions, conditional branching, scoring algorithms, and content of ACM Check based on these manual trials and expert reviews.

Phase 2: Creation of the Mobile App

We provided the final questionnaire and content to the software development company. ACM Check was initially developed for the iOS platform (Apple Inc). Developing the app first for one platform, then refining it before building the app for other platforms, is an efficient approach that minimizes the cost of iterating multiple versions [18]. We chose the iOS platform for the initial version due to the smaller number of devices for testing, and the fact that Apple had the largest market share in

Australia at the time of initial development [9]. After the initial build, we used TestFlight (Apple Inc) for iOS to beta test and debug ACM Check.

We then trialed the iOS version of ACM Check on a sample of metropolitan homes in Perth, Western Australia. We obtained user feedback to further improve the accuracy, functionality, and usefulness of the app before releasing it to the public. The iOS version of ACM Check was modified based on user feedback before being replicated and developed for Android (Google Inc). We released ACM Check to the public via the App Store (Apple Inc) and Google Play (Google Inc) in June 2017.

Results

The app delivers a self-administered, structured questionnaire that is supplemented with easy-to-follow instructions and images of ACMs. There are 3 modules that make up the questionnaire. The first module collects data on user and housing information, including state of residence, user description (eg, community member, householder, or DIY renovator; local government environmental health officer; or tradesperson working in residential settings), residential post code, period of house construction, type of dwelling, and number and age category of occupants. The second and third modules aim to identify potential ACMs located outside and inside the home, respectively. To do this, the questionnaire methodically guides the user through a visual inspection of locations around the house where key materials that may contain asbestos could be located. The outside locations inspected include the exterior walls and gable ends, eaves or soffit linings, roofing, gutters,

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downpipes, electrical meter box, fencing, and outbuildings. The inside locations inspected include the interior walls, cupboards and backsplashes, ceilings, flooring, and heater flues.

Questionnaire Design

The ACM Check questionnaire is a computerized, self-administered questionnaire that uses conditional branching ("skip logic") to assign each screened material a probability of containing asbestos, and subsequently to assign each potential ACM a priority level for action or remediation. The answers of the completed sections and modules are linked using if-then rules. For example, *if* the house was built before 1985 *then* it is highly likely to have ACM present. This feature results in a custom pathway being created through the questionnaire. Consequently, users are automatically navigated through the questionnaire in an efficient manner so that they do not need to read and answer all of the questions [19].

Screening for Asbestos-Containing Materials

The app uses multiple-choice questions to assess each location inside or outside the house (Figure 1). The information necessary for the visual identification of ACMs includes (1) the age of the house, (2) its renovation history, (3) the location or use of the ACM, and (4) visual features specific to each type of material.

The age of the house is relevant because, in Australia, asbestos was phased out of residential building products that were manufactured in the years leading up to 1987 [20]. However, builders or tradespeople may have had stockpiles of ACMs in their warehouses or trade centers that were used beyond that date. Therefore, we used a conservative cutoff date of 1990 in the app. More specifically, we used 3 categories for the probability that a house contains asbestos based on the age of the house to best reflect the years in which ACM use was phased out of residential buildings (Figure 1). We adapted these categories from rankings used by the Environmental Health Standing Committee [3]. The answer to this question also determines whether the full questionnaire or only sections of it will be administered to the user. If the house was built after 1990 (the date ACMs ceased to be installed in new housing), then an abbreviated questionnaire is administered that only asks questions relating to outside materials, such as fences or outbuildings, that could be present from earlier developments (Figure 1).

For pre-1990 homes, ACMs may have been replaced with non-ACMs. Therefore, each material screened in the app has a question relating to date of installation or its renovation history.

The final factor in screening for the likelihood of a material containing asbestos is to inspect the visual features. Although some ACMs appear visually identical to non-ACMs, other materials can have distinct visual features that indicate whether they are likely to contain asbestos.

Based on the user's answers to questions regarding these 4 factors, each material or location inspected is automatically designated as 1 of 4 probabilities of containing asbestos: not applicable, unlikely ACM, possible ACM, or likely ACM. The

designation of not applicable is used only for those materials or locations that are not present inside or outside of the home as indicated by the user. For example, not all properties have an outbuilding or a permanent internal heater, so when these are not present they are designated not applicable. The designation of possible ACM is used to highlight the situations where it is more difficult to confirm or rule out the probability that a material contains asbestos. This can be due to difficulties in visual identification, such as a lack of visual characteristics that distinguish ACM from non-ACM, or lack of information on the year of installation or the renovation history. For instance, if a user indicates they have eaves made of cement sheeting with joiner strips, but they do not know if they were installed before 1990 or replaced after 1990, then those eaves are designated as possible ACM.

Priority Assessment of Possible and Likely Asbestos-Containing Material

The mere presence of in situ ACMs in or around the home does not necessarily mean individuals are inhaling or being exposed to asbestos fibers, or that they are at an increased risk of developing an asbestos-related disease. Two key variables that need to be considered when looking at the risk of asbestos exposure in the residential environment are the current condition of the ACM and the likelihood of disturbing the ACM. For instance, an asbestos cement product that is in good condition and left undisturbed is associated with a minimal risk of asbestos exposure and presents a negligible health risk [5]. In contrast, an asbestos cement product in poor condition or that is accidentally or deliberately disturbed can result in dispersal of asbestos fibers into the air and is associated with a greater risk of exposure [5]. Therefore, a priority assessment that incorporates these 2 factors is triggered for each material that is designated a probability of possible or likely ACM.

The current condition is based on the degree to which the ACM shows signs of weathering, deterioration, or physical damage, such as surface marks, scratches, cracks, splits, breakages, or water damage, and on how friable it is; that is, how easily the material crumbles. There are 2 questions pertaining to the material's condition: a qualitative and a quantitative assessment. The qualitative question has 4 possible outcomes: "good," "fair," "poor," and "very poor." Descriptive text accompanies each option to help the user select the most appropriate answer. Additionally, the user is asked a quantitative question, which has the user rate the material on a scale of 1 (very poor) to 10 (very good).

The likelihood of disturbance refers to the probability of the ACM being damaged or disturbed in the near future. This reflects the chances of asbestos fibers being released from the material and made airborne, which subsequently increases the risk of their inhalation by occupants in their vicinity. ACMs can be disturbed for a variety of reasons, including through access, use, repair, or renovation and maintenance activities. The likelihood of disturbance is also presented as a multiple-choice question with the user having to select 1 of 4 answers: "unlikely," "somewhat likely," "likely," or "highly likely," which are accompanied by descriptive text.

Figure 1. Process flow chart showing the key factors used in the ACM Check app to determine the probability that asbestos is present in a material or location. ACM: asbestos-containing material.
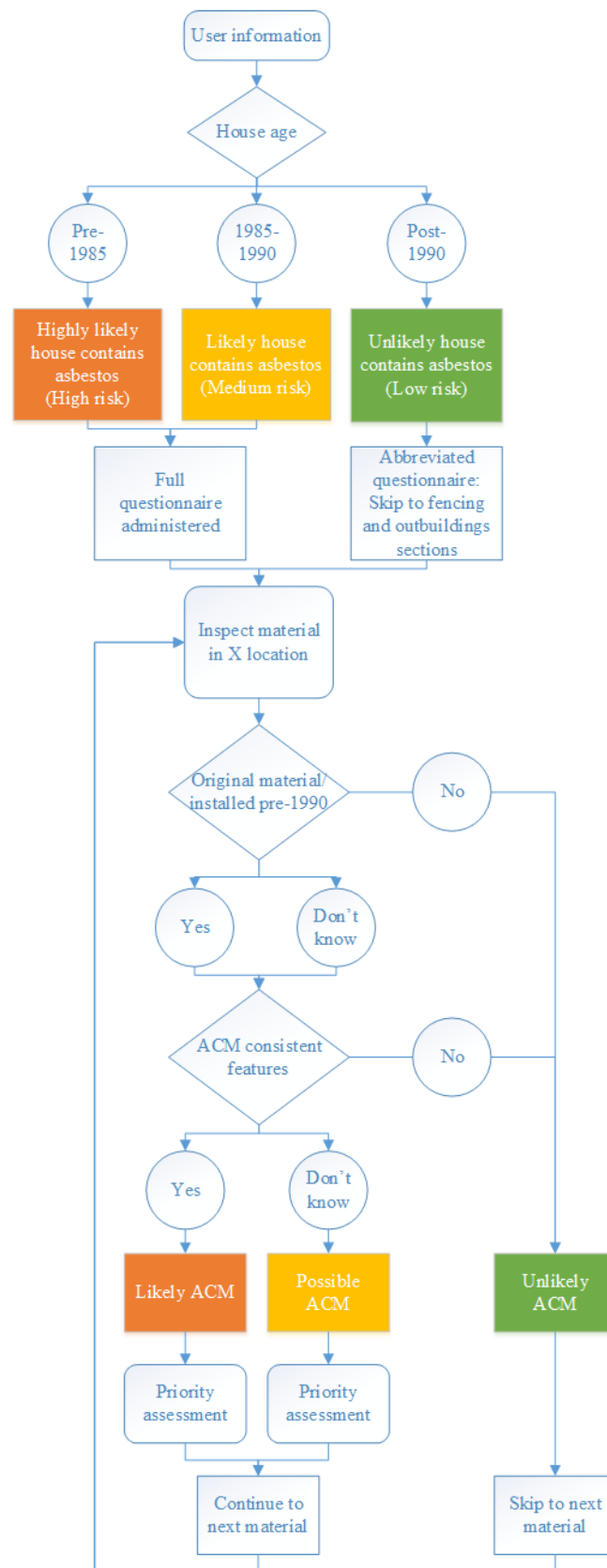
Figure 2. Risk matrix used to give a priority level for action or remediation to each possible or likely asbestos-containing material.

The answers to the questions on qualitative condition and likelihood of disturbance are assigned numerical values, which are then summed to provide an overall rating to the ACM, expressed as a priority level (Figure 2). The priority level, either "very low," "low," "medium," or "high" priority, indicates which ACMs are of most concern to that property with respect to the potential risk of asbestos exposure and which ACMs require remediation. For example, an ACM assigned as high priority should be given greater attention by the user and has a greater risk of releasing asbestos fibers than an ACM that is given a very low priority.

Summary Report

A summary report is generated after the inspection has been completed, which shows the user the probability of each material assessed containing asbestos, its current condition, the likelihood of disturbance, and the priority level for each possible or likely ACM (see Multimedia Appendix 1). Depending on the priority level, a general recommendation is provided for each ACM. These range in severity, from "Monitor and no immediate action necessary," "Monitor and minor maintenance and repair," and "Removal and replacement should be a priority. Major repair activity should be considered as a secondary and temporary action," through to "Consult an asbestos professional for removal, disposal and replacement of the ACM." These recommendations are presented in table format alongside the corresponding and color-coded priority level. Furthermore, each recommendation is accompanied by a description and links to further relevant resources where possible.

All summary reports are stored in the ACM Check Reports tab on the home screen for quick reference (see Multimedia Appendix 2). This allows users to complete the app on multiple homes, which is useful for owners of multiple properties or individuals who work in multiple residential settings.

Discussion

ACM Check is a screening tool designed to identify and assess the condition of potential ACMs in situ in residential settings. The app directs users to further information from reputable authorities pertaining to asbestos and its safe management. ACM Check can also be used as a data collection tool for researchers working with relevant government and nongovernment agencies to map the presence and condition of ACMs in the built environment. Furthermore, ACM Check is freely available to use to assist with asbestos identification and to raise awareness about the hazards of asbestos exposure.

In situ asbestos is an ongoing problem in Australia despite being phased out of residential building products during the 1980s. ACM Check offers a free, quick, and easy-to-follow solution that will aid in the prevention of exposure to in situ asbestos in the residential environment. ACM Check is, to our knowledge, the first and only mobile app available on the market that guides users through a visual inspection of the home from beginning to end in a systematic manner. To motivate people to use the app, we promoted ACM Check via live interviews on community radio stations, as well as through social media and Web posts by various not-for-profit organizations that target asbestos-related disease prevention and awareness. Furthermore, ACM Check was promoted on trade union and occupational health and safety-related websites to encourage workers to download and use the app.

The app could be adapted for use in other countries where ACMs were used in residential settings. The questions and rules are likely to need careful modification if this tool is to be adopted for use in another country with a history of asbestos use that is different from that in Australia. For instance, different countries may have phased out asbestos in different years (if applicable); have different regulations and prohibitions pertaining to asbestos use; and have different profiles, types, and frequencies of ACMs used in homes. Regardless, ACM Check offers a model that could be easily modified to accommodate country-specific

variables. Similarly, ACM Check could be expanded or modified to target asbestos in occupational settings, or used as a roadmap for new apps targeting the identification of other occupational hazards.

Limitations

ACM Check does not replace or eliminate the need for consultation with an asbestos professional. ACM Check attempts to capture the main sources and locations where ACMs are likely to be present in residential settings. However, it is impossible to capture all scenarios and materials that could contain asbestos in the residential environment due to the large and diverse uses of asbestos in the past [1].

Conclusion

ACMs are difficult for the untrained eye to identify in the built environment, but to prevent exposure to asbestos, identification is necessary. As a multidisciplinary team, we designed and developed a practical and easy-to-use mobile app, ACM Check, to screen for in situ ACMs in the residential environment. ACM Check forms part of a primary prevention strategy aimed at minimizing users' risk of exposure to asbestos fibers in the residential environment while doubling as a scientific data collection tool. This technology could be modified to raise awareness among the broader community about other environmental health issues.

Conflicts of Interest

JW is a director of Reach Health Promotion Innovations Pty Ltd. This company performed a paid contracting role in the ACM Check Project.

Multimedia Appendix 1

Sample report generated by ACM Check showing a summary of a completed inspection and the table of general recommendations.

[PDF File (Adobe PDF File), 55KB - formative_v1i1e7_app1.pdf]

Multimedia Appendix 2

Screenshots showing the home screen and sections of the questionnaire from the ACM Check app.

[PNG File, 667KB - formative_v1i1e7_app2.png]

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Abbreviations

ACM: asbestos-containing material
DIY: do-it-yourself

XSL•FO
RenderX