Identifying preferences for mobile health applications for self-monitoring and self-management: Focus group findings from HIV-positive persons and young mothers

Nithya Ramanathan[a], **Dallas Swendeman**[b,*], **W. Scott Comulada**[b], **Deborah Estrin**[a], and **Mary Jane Rotheram-Borus**[b]

Nithya Ramanathan: nithya@cs.ucla.edu; Dallas Swendeman: cchpublications@mednet.ucla.edu; W. Scott Comulada: scomulad@ucla.edu; Deborah Estrin: destrin@cs.ucla.edu; Mary Jane Rotheram-Borus: mrotheram@mednet.ucla.edu

[a]Center for Embedded Networked Sensing, Department of Computer Sciences, University of California, Los Angeles, United States

[b]Semel Institute Center for Community Health, Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, United States

Abstract

Objective—Self-management of risk behaviors is a cornerstone of future population health interventions. Using mobile phones for routine self-monitoring and feedback is a cost-efficient strategy for self-management and ecological momentary interventions (EMI). However, mobile health applications need to be designed to be highly attractive and acceptable to a broad range of user groups. To inform the design of an adaptable mobile health application we aimed to identify the dimensions and range of user preferences for application features by different user groups.

Methods—Five focus group interviews were conducted: two ($n = 9$; $n = 20$) with people living with HIV (PLH) and three with young mothers ($n = 6$; $n = 8$; $n = 10$). Thematic analyses were conducted on the focus group sessions' notes and transcripts.

Results—Both groups considered customization of reminders and prompts as necessary, and goal setting, motivational messaging, problem solving, and feedback as attractive. For PLH, automated and location-based reminders for medication adherence and sharing data with healthcare providers were both acceptable and attractive features. Privacy protection and invasiveness were the primary concerns, particularly around location tracking, illegal drug use, and sexual partner information. Concerns were ameliorated by use scenario or purpose, monetary incentives, and password protection. Privacy was not a major concern to mothers who considered passwords burdensome. Mothers' preferences focused on customization that supports mood, exercise and eating patterns, and especially using the mobile phone camera to photograph food to increase self-accountability.

Conclusions—Individualization emerged as the key feature and design principle to reduce user burden and increase attractiveness and acceptability. Mobile phone EMI uniquely enables individualization, context-aware and real-time feedback, and tailored intervention delivery.

1. Introduction

1.1. Background

Healthcare costs are continuing to rise due to increasing burdens of chronic disease, which are the largest causes of death globally [1] and account for the majority of health care costs, for example, 78% of health care costs in the U.S. [2]. Changing daily routines for eating, exercising, stress, medical adherence, disease transmission risks, and alcohol, tobacco and other drug use can significantly improve health and reduce health care costs over time. Preventive behavioral interventions, based mostly on face-to-face counseling models, have had limited diffusion due to relatively high costs, logistical barriers, and high stigma associated with counseling [3]. Self-management or self-directed interventions are increasingly advocated to address these challenges [4]. Self-management interventions have been found to have positive impacts with a wide range of behaviors and user groups such as improved eating, physical activity, and stress management (i.e., relaxation, mood and coping) with people managing diabetes and heart disease risk [5–8] and increased stress-management behaviors and adherence to medication regimens, reduced substance use and transmission risk behaviors, and improved quality of life for people living with HIV [9,10]. Self-management and healthy lifestyle promotion for the prevention of disease require similar cognitive processes to transform intentions into behavior: capacity for self-evaluation; self-managed action with task- and time-specific, outcome-focused goal setting; and behavioral analysis to identify triggers (antecedents) and reinforcements for desired and undesired behaviors [11,12]. Thus, self-monitoring and feedback are the two most critical components of self-management [13,14].

Mobile phones offer the potential to broadly and cheaply diffuse more intensive self-monitoring, feedback, self-management and clinical support than has been possible previously. Mobile phones offer affordable, proximate, personalized, and continuous measurement in context. "Always on" and "always worn", mobile phones can provide an intimate and detailed picture of an individual's daily routines. This is especially true for smartphones, which support a diverse set of datastreams: automated traces of actigraphy, location, and other data that can infer physical activities, sleep, and environment; automated and manually entered physiological measures (e.g., readings from a glucose meter); and prompted and user-initiated self-reports of the user's symptoms, behaviors, or environment in the moment. Time, location, actigraphy, and self-report data datastreams, appropriately managed, can be leveraged to trigger highly personalized interventions, and thus significantly improve an individual's ability to understand and manage his or her own behaviors.

Three overlapping research methods have been used for daily or more frequent monitoring of behaviors and states of individuals acting in their natural contexts; the experience sampling method (ESM) [15], ambulatory assessment [16], and ecological momentary assessment (EMA) [17]. Triggering interventions using this data has recently been termed ecological momentary intervention (EMI), which provide real-time and context-aware interventions that occur with minimal disruption in individuals' daily lives [18]. Mobile phone based EMI has the potential to both supplement existing clinical care (e.g., through mobile monitoring between clinic visits), and offer behavioral self-management support. For example, Burns et al. [19] recently piloted a mobile EMI for depression that used a machine

learning process based on self-reported mood states and mobile-sensed context data (e.g., location) to predict future mood states. In turn, predicted mood states provided valuable feedback to mobile users and enabled context-related clinical responses.

1.2. Objectives

The potential impact of mobile EMI or self-management applications is dependent on their scalability and adaptability to be acceptable and attractive to diverse user groups and priorities. In order to ensure broad availability, adoption, and utilization, robust and tailorable platforms that can address diverse user groups are needed [20]. In this paper we report on findings from five focus group interviews with two diverse user groups: young mothers focused on diet, stress, and physical activity; and people living with HIV (PLH) focused on medication adherence, stress, emotional distress, substance use and sexual risk behaviors. These dissimilar populations serve to inform the development of platforms that can address a broad range of user needs by spanning a range of sensitive behaviors (sexual interactions and illegal drug use) to less stigmatized behaviors (diet, stress, exercise). The objective of this study is to identify the dimensions and ranges of issues that potential users anticipate may be important or salient to themselves or others in order to inform the development of robust, tailorable and adaptable mobile phone self-management EMI platforms and applications.

1.3. Literature review of feasibility studies

The evidence-base on feasibility and user preferences for mobile health applications is relatively limited and nascent. Researchers have conducted acceptability and feasibility studies for ecological momentary assessment (EMA) with personal digital assistants and mobile phones more recently, in which users are instructed and prompted to complete several assessments a day. Reviews of the EMA literature demonstrate that electronic EMA is acceptable and feasible for a variety of populations and health domains, even for marginalized populations and those with special needs, such as the elderly, individuals of low socioeconomic status, children, drug users, and individuals suffering from psychopathology [21].

Mobile phone-based EMA studies, on the other hand have only really begun in the past few years [21] and mobile-EMI is even more innovative [18]. Thus, there is relatively little literature published on user preferences for mobile EMI. Therefore, we use the literature derived from pen-and-paper and pocket computer-based EMA studies, as well as several recent mobile EMA studies, to identify key domains to consider when studying user preferences around mobile-EMI. Although different end user populations may have very different needs and preferences for mobile EMI support, we hypothesize that there are robust and essential features of mobile phone EMI support tools that need to be considered when tailoring design preferences across and within target populations and health domains. Domains emphasized in the current literature emphasize participation incentives and feedback, self-monitoring or survey burden, user input modality, image capture, and privacy and data security.

1.3.1. Incentives and feedback—Regardless of preferences, user buy-in is a necessary first step, whether through promise of material or other incentives and motivators. For example, Christensen et al. [22] have successfully used monetary incentives of $20 per week, small tokens (e.g., candy), and weekly prize drawings beyond a week to increase compliance to EMA. Beckham et al. [23] paid participants an extra $25 for missing less than three data entry prompts per day. Beyond money and gifts, Hektner et al. [15, pp. 51–52] have found that information and feedback are also valued incentives, which has important implications for the cost-effective scalability of mobile EMI.

1.3.2. Self-monitoring burden and prompt frequency—Another key concern in application design is the avoidance of user fatigue that is more likely with frequent assessment in EMA. In their review of studies where participants were prompted from a signal such as a beeper, Reis and Gable [24] found the average number of signals to be between 56 and 168 over 1–2 weeks, translating to between 4 and 24 prompts per day on average. Shiffman et al. [21] found three to five assessments per day to be common across EMA studies and therefore likely to be feasible and acceptable. Yet, for some domains or populations only once daily "diary" or weekly reports are sufficient for effective self-monitoring or to inform subsequent EMI triggering. The length of assessment is also crucial. Hektner et al. [15] recommend that assessments takes 1–2 min to complete, once participants are familiar with the format.

1.3.3. User input modalities—Text messaging, and especially multi-media messaging, has been found to be attractive to groups of mobile users [25,26]. Horvath et al. [27] found positive reactions to regular web-based diary assessment among predominately white gay men who were recruited through a chat room, reflecting their communication platform usage patterns. Wiehe et al. [28] found that adolescent women enrolled from a clinic-based setting were comfortable making diary entries on their mobile phones, but were less comfortable in using the Internet and texting functions regularly on the phone.

1.3.4. Cameras and image capture—Another common mobile phone feature to capture context is the camera. Visual information has been appealing to participants in some settings. For example, Martin et al. [29] found high satisfaction among participants to assess energy food intake by taking pictures of their meal selections and plate waste as opposed to written reports.

1.3.5. Privacy, data security, and geo-location—Privacy issues also need to be considered in the expanded and often intrusive features offered by mobile EMI, especially in marginalized or special populations. In some instances, peer perceptions also need to be considered. For example, in their study of adolescent women, Wiehe et al. [28] found some participants' peers were threatened by location monitoring of participants' GPS-enabled phones.

2. Methods

Focus groups were conducted in 2010 with two populations of mobile phone users: people living with HIV and young mothers. The focus groups were presented with hypothetical mobile health application features and use scenarios (i.e., for research, clinical support, and self-management purposes) to seed discussion of their preferences and concerns. Major categories covered were: *privacy* (including selective data sharing and password protection), *goal setting*, *feedback on behaviors*, *methods for data capture* (including images), and *reminders*. Focus group participants were queried by the focus group facilitator about the feasibility, acceptability, and attractiveness of potential features of a mobile health application platform being developed by the authors. Questions also covered topics related to mobile phone assessment including user burden, prompts and reminders, and privacy; and to mobile phone based intervention including goal setting and motivational messaging. Focus groups for each user group were recruited and conducted until the themes elicited became redundant across groups and no new themes emerged (at the second group for PLH and third group for mothers). Thematic analyses [30] were conducted from the qualitative data that included the audiotaped recordings of the focus group interviews and extensive notes taken during the interviews by the study's first author and research assistants. The Institutional Review Board, Human Subjects Protection Committee, of the University of California at Los Angeles reviewed and approved the focus group protocols.

2.1. Persons living with HIV (PLH)

Two focus groups with ($n = 9$) and ($n = 20$) PLH were conducted as part of a pilot study to inform the design of a mobile phone application to self-monitor and self-manage four inter-related health behaviors and risk factors among PLH: medication adherence, drug use, sexual behaviors, and emotional distress. The focus group participants were ethnically diverse (about one third in each ethnic group: African American, Latino, and White) and ranged in age from about 30 to 60. Most participants were men (75%) and just over half were men who have sex with men (55%). About 10% of participants were transgender and 10% were injection drug users. The participants were economically disadvantaged food bank recipients recruited at a large AIDS service organization in Los Angeles and representative of potential users with the highest need for self-management support. Given the sensitive nature of the domains of interests, the focus group discussion was framed around participants' anticipated comfort level with reporting and sharing data and receiving feedback on the proposed mobile phone application in different use contexts: research, self-management, and clinical support and counseling (i.e., medical care, therapy, substance abuse or risk reduction counseling).

2.2. Mothers

Three focus groups with ($n = 6$), ($n = 8$) and ($n = 10$) mothers were conducted as part of a larger study to inform the design of a mobile application to study cardiovascular risk factors in mothers: diet, stress, and exercise. Basic measurement parameters include participants' daily exercise routines, diet, and stress and mood levels throughout the day, measured by survey; and a participant's mobility, recorded continuously using our automated mobility classifier. The mothers ranged in age from 18 to 35 years old, were ethnically diverse women (10 Caucasian, five African American, four Latina, and five Mixed/Other), with about one half employed outside the house. Participants were recruited and screened from medical practices, hospitals, parks, farmers markets, churches, and other community gathering spots.

3. Results

Salient themes in the discussions varied significantly across the two user populations. PLH discussions focused on issues of privacy, purpose of application, incentives, and a reminder system to assist with medication adherence or other health behavior goals. Discussions with mothers focused on features to engage users and incentivize participation since they were not concerned about privacy for the domains of interest (diet, exercise); they were most concerned that the many benefits of the health monitoring mobile phone application not be out shadowed by the burden involved in responding to the surveys. Despite different focal points, there was a fair degree of overlap in discussion themes, presented in Section 3.1 below. Themes that were especially relevant for PLH are presented in Section 3.2 and for mothers in Section 3.3. Table 1 summarizes the common and distinct themes emerging from the focus group discussions.

3.1. Themes relevant to both PLH and mothers

3.1.1. Prompt frequency and survey burden—Both groups agreed that three to four surveys per day were acceptable; controlling timing of surveys was attractive and necessary to all, but especially so to mothers. PLH discussions broadly noted that more frequent surveys were less acceptable, but that monetary incentives increased acceptability of heavier survey burden and in the moment prompts.

"It depends on if you pay me."

Many mothers were willing to respond in the moment, especially if it was a brief survey. Mothers were also interested in some form of end of day survey: some mothers wanted to report on the events of the day only at the end of day (i.e., akin to a diary and for reflection), while many wanted to respond briefly in the moment and then elaborate at the end of the day.

> "I don't want to answer a survey when I'm stressed because I think it will bias my response."

3.1.2. Self-management support tools: goal setting, reminders, and feedback

—Goal setting, motivational messaging, and problem solving were considered attractive to both groups. The ability to set, manage, and monitor progress toward goals was an important motivation for using a mobile EMI self-management tool. PLH found the concept of motivational messages and goal reminders to be potentially valuable to help adhere to medications, stress management, and sexual risk and substance abuse reduction goals, although not all domains were applicable to all participants. Some PLH recognized the value of problem solving support:

> "It would be a reminder, a helpful way to stay on track."

> "It could help [people] to stay safe."

> "It would be a personality check."

Many mothers said they would participate in a mobile EMI if it was part of a goal setting regimen. Mothers also wanted the progress monitoring and motivational messages to occur daily or weekly, with some divergence in opinion regarding the specific content of the messages to help them achieve a goal. Mothers wanted helpful tips from a group of peers using the application (e.g., recipes, alternative food options) or motivational messages possibly even in comparison to others.

> "Goals would be helpful, I don't want to just answer questions for no reason."

> "I'd like a reminder to change up my routine, such as a no sugar day."

> "I want helpful tidbits, such as 'walking faster burns more calories' or 'burning 300 calories per week will help you lose 5 lbs'."

> "The app could say 'you did this much exercise, if you exercise 10 more minutes you will meet your daily goal'."

Support for problem solving was also important for some mothers.

> "Perhaps the application could ask me to reflect on one specific stressful event, one that stood out and will probably re-occur. And ask questions like 'did you handle the situation to the best of your ability.' and 'What could you have done differently'."

Reminders were important across both groups, primarily for medication adherence for PLH and general assessments for mothers. Participants felt reminders to take medication when they were at home would be especially attractive, as that is the only location they would like to take their medication for reasons of privacy and convenience. PLH discussions primarily focused on reminders for two domains: to take medication and refill prescriptions, to help improve adherence to onerous medication regimens (a few participants reported experience with their doctors programming reminders into the mobile phone's alarm feature or as part of an SMS system); and to encourage safe sex (e.g., condom use) would be helpful if provided prior to a potential sexual encounter but not after.

> "It would have to be before somehow, not after, it's not helpful after the fact."

Location based triggers were proposed for the sexual behavior reminders, based on prior data reported by the Participants found this potentially helpful but also potentially invasive, especially in the context of sexual behaviors and drug use.

"It's too much information, too personal."

Customization of prompts and reminder schedules was considered necessary by all. This was especially true for mothers, who agreed that surveys must be timed to be convenient (while researchers focused on the need to time surveys to capture specific events like eating, or regular sampling).

"I'm more likely to answer a survey if I can determine when I complete it."

The most common barrier listed by mothers was completing surveys at an inconvenient time, especially during a stressful event, while driving, or while children were around. Random reminders, or having to remember to complete a survey after every meal (without a reminder), were also felt to be problematic.

Feedback to identify anomalous behaviors and connections between behaviors was of interest to some across both groups. Interested PLH spontaneously recognized the value of self-directed reflection on summaries of data visualized by time, location, and in association with the other domains assessed.

"It might be helpful to recognize patterns, but it might be hard to confront. Because it might be scary, I'd want to look at it by myself."

"It's good AND bad – you can see things you want to correct, but…"

Some mothers wanted to see trends, patterns, and anomalies highlighted over time, see trends or connections across behaviors, and identify people or social contexts that trigger negative behaviors.

"I would love to know how my mood and energy levels are impacted by food and exercise."

"I want to know what environments and what people stress me out."

There was, however, a noted lack of enthusiasm for feedback in the form of data summaries, which was surprising as this tends to be the most common feature provided by data collection services (including our own). Although some PLH recognized the value of data summaries as part of an overall support program, and for self-reflection and self-awareness, they did not have strong opinions about the feedback format.

"I don't need to see a graph to know what's going on in my life, but I know other people who aren't so self-aware, and could use an app like this."

Mothers agreed that simple quantifications of data, without supplemental analyses to highlight trends, patterns, or anomalies, would not be that useful.

"I want more detailed questions to help me figure things out. I don't like simple questions about what happened, I want questions that help me understand why."

3.2. Themes especially relevant to PLH

3.2.1. Data privacy and sharing—Privacy was especially important for PLH. While some PLH understood the value of data sharing, and were willing to share data in specific instances (such as with a clinician), they expressed many concerns about privacy, especially given the sensitive nature of the data being collected (including location traces, and questions regarding alcohol or illegal drug use).

"It's one thing to fill out a paper survey but the phone would feel weird."

"It's none of their business!"

"That's the limit, that's going too far."

Control over location tracing was considered necessary because location tracing was a controversial subject for most participants, particularly around illegal drug use and to a lesser extent around sexual behaviors.

"Don't track me, no!"

"THEY know where you are."

Participants recognized the potential value and positive impact of location based prompts and reminders for clinical and self-management support, while expressing concerns about privacy and intrusiveness. Acceptability was heavily dependent on the use scenario and purpose.

"It depends – what's the scenario? If it is for a research study, for a good cause, then it is okay."

"If you volunteer for some thing [a study], you shouldn't get in trouble."

3.2.2. Data sharing—Factors associated with acceptability of sharing sensitive data included being used for research having a societal or personal benefit, the latter being study incentives. Data sharing was acceptable with a counselor, coach, or medical provider if the data were secure, as some participants did not trust the security of their medical records with clinic staff.

"As long as I knew they [data recorded on phones] were secure, and only one person could access them."

The other factor that mediated participants comfort with sharing data was the content of the data. Participants were generally comfortable reporting and sharing medication use data. Emotional distress data sharing was acceptable if the reports were not taken out of context to result in intervention by a healthcare provider.

"Being really honest [with doctors, treatment] doesn't always pay, for me."

"People take it [information about a bad mood] the wrong way. Doctors sometimes take things the wrong way and overreact."

Sexual behavior data sharing was generally acceptable but not name-based reporting of sexual partners. Data related to illegal drug use was of most concern due to potential for police intervention and incrimination by getting data off the phone.

"Cell phones can be tapped, the government, police, phone companies [another participant responds] they'd need a warrant to tap your phone [another responds] no, they can go around it [another responds] Yeah, it's been done."

3.2.3. Privacy protection—Password protections, immediate data transfer off of phone, and data encryption ameliorated privacy concerns. PLH discussed either password protection on the phone and/or password protection for accessing the application as a necessary feature due to the sensitive nature of the data that would be collected.

"Yeah, because it's going straight to a computer – doctor or whoever's doing the study."

By contrast, mothers did not feel the data on diet, stress, mood, or physical activity were particularly sensitive and so did not consider password protection necessary or even beneficial. In fact, mothers considered password entry upon completing each survey to be a barrier to participation.

3.3. Themes especially relevant to mothers

3.3.1. Image capture—The ability to capture and tag pictures of food was especially engaging for mothers. Images provided accountability that could not be attained through surveys responses. Almost all mothers were excited or motivated by taking pictures of their food on the phone, making this a powerful tool for engagement. Images were seen to represent accountability, increasing one's adherence to a plan.

> "A picture of my plate after a meal would help improve my behavior."

> "A picture will improve my motivation."

> "The picture doesn't lie."

Interestingly, mothers did not find it acceptable nor understand the purpose of taking pictures of anything else other than food.

> "Even if data is kept private, I wouldn't be willing to take pictures of people."

PLH also had difficulty identifying the utility or value of image capture for the domains of interest, in addition to privacy concerns around sexual behavior and especially substance use.

3.3.2. Modality to access data—Most mothers felt it would be inconvenient to have to access a computer or log on to a website, and wanted all or most of their interaction to take place directly on the smartphone. Several thought they would be willing to visit a website to do one-time configuration, but after that wanted only phone interaction, and a few mothers said they wanted to access a webpage monthly. Preferences for web or phone based data access varied across PLH but the overall discussion suggested that multiple ways to access data were preferred.

3.3.3. Light-weight 'stress button'—The burden and potential bias in survey responses (especially if requested to answer questions about a stressful event immediately after the event) led to the suggestion made by mothers for a 'light-weight' data collection mechanism in most of the focus groups, and eventually led us to develop the concept of a '*stress button*'.

This button would be located on the phone's main screen, and would be a light-weight mechanism to quickly record the time and location of a stressful event, but would not prompt the user for any additional information. The 'stress button' abstraction can be generally applied to any event, and was considered very attractive by end-users.

3.3.4. Annotation and reflection—Ideally the application would allow and even prompt further reflection and explanation of the event at a later time that was more convenient. This end of day reflection was especially important because mothers felt that their responses might be biased if they were forced to answer a survey while they were stressed.

> "Perhaps a brief question during the day that can then be followed by specific questions would help me reflect on the day."

4. Discussion

Our collaborative inter-disciplinary team is developing an open-source mobile health platform for personal, individual-level self-monitoring and feedback around health behaviors and states that can be tailored to many health problems or domains of interest [20]. Feasibility studies and more in depth exploration of user preferences are an essential strategy to help design broadly scalable mobile EMI platforms. As Heron and Smyth [18] note, most of the current evaluations of mobile-based EMI has occurred with little communication between researchers and clinicians across disciplines. This is especially problematic if mobile health applications are to be brought to scale in the healthcare field. Our inter-disciplinary team, including researchers from computer science, psychology, social and behavioral sciences, and bio-statistics, brings a unique and integrated perspective to the challenge of developing a broadly scalable and adaptable mobile EMI platform. Our work with two very different populations and domains of interest (i.e., young mothers managing weight and PLH managing medications and risk behaviors) highlights the commonalities and variations in anticipated user preferences both across and within these diverse groups.

In this paper, we address preferences that are paramount across EMA, including the incentive structure and survey fatigue. We also address issues that uniquely arise with the introduction of mobile phones, which can collect more sensitive and potentially intrusive data, such as images and location, and make this data available frequently and publicly. It is important to recognize that our findings are in reference to hypothetical and early prototype design features of a mobile health application platform. Preferences, acceptability, and attractiveness of features could vary throughout a user's actual usage experience. For example, the mothers' lack of concern about password protections might change after actually using the application. Thus, we plan to follow up on mothers' and PLHs' experiences and preferences regarding privacy and other features after they have used the applications in our next phase of pilot studies. Nevertheless, this study provides an important step in informing the design features relevant to mobile self-management EMI, not just features to facilitate data collection that have been the focus of most prior EMA feasibility studies.

It is also important to note that user preferences can depend on multiple factors: the characteristics of the population, the domains under study, and the framing of the focus group questions and resulting discussions. In this study, while the focus groups were conducted and analyzed by the same team and the questions regarding application features were similar, each set of focus group questions were applied to very different domains, and the resulting discussions were dynamic with different emphases and follow up questions emerging for the two user groups. The application features and preferences had different levels of salience in the focus group discussions for the two populations. Mothers' questions focused on frequent monitoring of diet, stress, and exercise, and their discussions tended to center around reducing user burden and methods to help them improve these behaviors. PLH questions focused on monitoring sensitive behaviors, such as illegal drug use and sexual behaviors, so participant discussion centered on privacy and the associated purpose or use of the data. Privacy discussions in this population were further framed based on preferences given different use conditions, such as research, behavior change, and clinical support, and less on acceptability of feature preferences that were not salient to privacy concerns. The variations in question and discussion framing represent a limitation to direct comparisons of specific feature preferences across the two groups, while also serving to highlight the importance of the different themes that emerged across and within groups.

Similar to findings from prior EMA studies, we found similar preferences for basic data entry (e.g., three to five surveys and reminders a day) to be acceptable [21,15, pp. 41–42]. Another important point that has been raised by other researchers is the different incentive structures that EMI may require [15,22,23]. While PLH, more so than mothers, did suggest that monetary incentives were highly relevant, the additional burden introduced by the mobile phone may increase the need for stronger incentives. Discussion with both groups hinted at very viable incentive structures through the benefit of information on their behaviors and useful feedback. The daily availability of EMI (e.g., for medication reminders for PLH) may offer cost-effective incentives for long-term compliance compared to monetary incentives.

Two novel contributions from this study compared to themes represented in the current literature were the limited desire to interact with other participants and concerns about privacy. Our focus group participants expressed limited interest in interacting with other participants (although some expressed a potential interest in sharing recipes or other tips with each other). Other studies have reported participants having high interest in interacting with others, for example, in a smoking cessation program [25]. This difference could be attributable to insufficient focus on behavior change in the focus groups or specificity in the questions on this topic. In addition, while privacy was a significant concern and focus for PLH in our focus groups, consisting mostly of ethnic minorities and gay men, another study of gay men who were regular Internet users were reportedly comfortable recording sexual activity on a web-based diary [31]. The difference in our findings with existing literature underscores the need to conduct consumer preference studies in a specific target population early in the design process before and during deployments of mobile health applications.

In this study, individualization and granular control over functionality (hereafter referred to as 'customization') emerged as the key feature and design principle to both reduce user burden and increase the attractiveness and acceptability of the mobile EMI platform. In fact, the use of a mobile phone uniquely facilitates customization of features either through manual configuration or automated learning, and is therefore an important and relevant finding for this study. Customization of reminders, specifically their timing, was important to both groups as a key feature to reduce user burden. PLH were also interested in customized reminders, especially location based reminders for EMI delivery, such as medication reminders which triggered only when the participant is at home. Customization also spans to privacy. PLH wanted the ability to control which data was shared, with whom, and how, especially as pertaining to location data. And while PLH wanted additional security features such as passwords, mothers considered frequent password entry to be an unnecessary burden and a barrier to participation. Therefore, to enable broad adaptability of mobile health applications to various user preferences, such features should have the ability to activated or deactivated.

Both groups were especially interested in feedback and behavior change mechanisms (e.g., goal setting), an integral part of self-management and EMI. Customization is again critical, as preferences on content, frequency, appearance, and delivery modality varied significantly across populations. Mothers considered feedback and motivational messages that would allow them a more in depth look at their daily routines to be especially attractive and engaging, while PLH expressed mixed views on feedback depending on the domain.

5. Conclusion

The introduction of mobile phones for EMA and EMI uniquely enables customization, real-time feedback, and tailored intervention delivery, and is therefore highly attractive and engaging to participants and researchers alike. The variation in preferences, frequency, and

appearance, as well as the direct requests by participants (and researchers) for granular control over functionality indicates the need for a system that supports authoring and configuration by individuals as well as researchers. We were encouraged that the issues brought up were addressable and also highlight the possibility that once participant buy in is achieved, the daily availability of EMI (e.g., for medication reminders), may offer greater potential than traditional behavioral interventions for some behaviors.

Acknowledgments

References

1. Yach D, Hawkes C, Gould L, Hoffman KJ. The global burden of chronic diseases: overcoming impediments to prevention and control. JAMA. 2004; 291(21):2616–2622. http://dx.doi.org/10.1001/jama.291.21.2616. [PubMed: 15173153]

2. Anderson G, Horvath J. The growing burden of chronic disease in America. Public Health Rep. 2004; 119:263–270. http://dx.doi.org/10.1377/hlthaff.28.1.64. [PubMed: 15158105]

3. Miller RL, Shinn M. Learning from communities: overcoming difficulties in dissemination of prevention and promotion efforts. Am J Community Psychol. 2005; 35(3–4):169–183. [PubMed: 15909793]

4. Bodenheimer T, Lorig K, Holman H, Grumbach K. Patient self-management of chronic disease in primary care. JAMA. 2002; 288(19):2469–2475. jip21007 [pii]. [PubMed: 12435261]

5. Glasgow RE, La Chance PA, Toobert DJ, Brown J, Hampson SE, Riddle MC. Long-term effects and costs of brief behavioural dietary intervention for patients with diabetes delivered from the medical office. Patient Educ Couns. 1997; 32(3):175–184. S0738399197000396 [pii]. [PubMed: 9423499]

6. Skinner TC, Carey ME, Cradock S, Daly H, Davies MJ, Doherty Y, et al. Diabetes education and self-management for ongoing and newly diagnosed (DESMOND): process modelling of pilot study. Patient Educ Couns. 2006; 64(1–3):369–377. [PubMed: 17011154]

7. Steed L, Lankester J, Barnard M, Earle K, Hurel S, Newman S. Evaluation of the UCL diabetes self-management programme (UCL-DSMP): a randomized controlled trial. J Health Psychol. 2005; 10(2):261. [PubMed: 15723895]

8. Lorig K, Holman H. Arthritis self-management studies: a twelve-year review. Health Educ Quart. 1993

9. Gifford AL, Groessl EJ. Chronic disease self-management and adherence to HIV medications. J Acq Immun Def Synd. 2002; 31:S163.

10. Gifford A, Sengupta S. Self-management health education for chronic HIV infection. AIDS Care. 1999; 11(1):115–130. [PubMed: 10434987]

11. Watson, D.; Tharp, R. Self-directed Behavior: Self-modification for Personal Development. Wadsworth; Belmont, CA: 2002.

12. Purdie N, McCrindle A. Self-regulation, self-efficacy and health behavior change in older adults. Educ Gerontol. 2002; 28(5):379–400. http://dx.doi.org/10.1080/03601270290081353.

13. Chodosh J, Morton SC, Mojica W, Maglione M, Suttorp MJ, Hilton L, et al. Meta-analysis: chronic disease self-management programs for older adults. Ann InternMed. 2005; 143(6):427–438. 143/6/427 [pii].

14. Creer, T.; Holroyd, K.; Glasgow, R.; Smith, T. Health psychology. In: Lambert, M., editor. Bergin and Garfield's Handbook of Psychotherapy and Behavior Change. Wiley & Sons; New York: 2004. p. 697-742.

15. Hektner, JM.; Schmidt, JA.; Csikszentmihalyi, M. Experience Sampling Method: Measuring the Quality of Everyday Life. Sage; Thousand Oaks: 2007.

16. Fahrenberg, J.; Myrtek, M., editors. Progress in Ambulatory Assessment: Computer-Assisted Psychological and Psychophysiological Methods in Monitoring and Field Studies. 1. Hogrefe & Huber; Seattle, WA: 2001.

17. Stone, AA.; Shiffman, S.; Atienza, AA.; Nebeling, L. The science of Real-time Data Capture: Self-reports in Health Research. Oxford University Press; New York: 2007.

18. Heron, K.; Smyth, J. Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments; Br J Health Psychol. 2010. p. 1-39.http://dx.doi.org/10.1348/135910709X466063

19. Burns MN, Begale M, Duffecy J, Gergle D, Karr C, Giangrande E, Mohr DC. Harnessing context sensing to develop a mobile intervention for depression. J Med Internet Res. 2011; 13(3):e55. http://dx.doi.org/10.2196/jmir.1838. [PubMed: 21840837]

20. Estrin D, Sim I. Open mHealth architecture: an engine for health care innovation. Science. 2010; 330(6005):759–760. [PubMed: 21051617]

21. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annu Rev Clin Psychol. 2008; 4(1):1–32. http://dx.doi.org/10.1146/annurev.clinpsy.3.022806.091415. [PubMed: 18509902]

22. Christensen TC, Barrett LF, Bliss-Moreau E, Lebo K, Kaschub C. A practical guide to experience-sampling procedures. J Happiness Stud. 2003; 4(1):53–78.

23. Beckham JC, Wiley MT, Miller SC, Dennis MF, Wilson SM, McClernon FJ, et al. Ad lib. smoking in post-traumatic stress disorder: an electronic diary study. Nicotine Tob Res. 2008; 10(7):1149–1157. [PubMed: 18629724]

24. Reis, H.; Gable, S. Event Sampling and Other Methods for Studying Daily Experience. Cambridge University Press; Cambridge: 2000.

25. Whittaker R, Maddison R, McRobbie H, Bullen C, Denny S, Dorey E, et al. A Multimedia mobile phone-based youth smoking cessation intervention: findings from content development and piloting studies. J Med Internet Res. 2008; 10(5):e49. http://dx.doi.org/10.2196/jmir.1007. [PubMed: 19033148]

26. Cornelius, JB.; Cato, M.; St Lawrence, J.; Boyer, CB.; Lightfoot, M. Development and pretesting multimedia HIV-prevention text messages for mobile cell phone delivery. J Assoc Nurses AIDS Care. 2011. S1055-3290(10)00224-4 [pii], http://dx.doi.org/10.1016/j.jana.2010.11.007

27. Horvath KJ, Beadnell B, Bowen AM. A daily web diary of the sexual experiences of men who have sex with men: comparisons with a retrospective recall survey. AIDS Behav. 2007; 11(4): 537–548. http://dx.doi.org/10.1007/s10461-007-9206-y. [PubMed: 17318430]

28. Wiehe S, Carroll A, Liu G, Haberkorn K, Hoch S, Wilson J, et al. Using GPS-enabled cell phones to track the travel patterns of adolescents. Int J Health Geogr. 2008; 22 http://dx.doi.org/10.1186/1476-072X-7-22.

29. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, Anton SD. A novel method to remotely measure food intake of free-living individuals in real time: the remote food photography method. Br J Nutr. 2009; 101(3):446–456. S0007114508027438 [pii], http://dx.doi.org/10.1017/S0007114508027438. [PubMed: 18616837]

30. Ryan GW, Bernard HR. Techniques to identify themes. Field Methods. 2003; 15(1):85.

31. Bowen AM, Williams ML, Daniel CM, Clayton S. Internet based HIV prevention research targeting rural MSM: feasibility, acceptability, and preliminary efficacy. J Behav Med. 2008; 31(6):463–477. http://dx.doi.org/10.1007/s10865-008-9171-6. [PubMed: 18770021]

Summary points

What was known before the study

- Mobile phones are deeply embedded into the lives of most people around the world and in particular Americans who on average use a mobile phone 3 h per day.

- Ecological momentary interventions, with real-time and context-aware assessments are significant to behavioral self-management.

- Self-management interventions are found to have positive impacts on a variety of patient populations seeking to alter various behavioral challenges.

- Self-managed or self-directed interventions are increasingly a necessary component to behavioral interventions due to rising healthcare costs, barriers to access and stigma associated with traditional methods.

- Mobile phones offer the potential to greatly expand more intensive self-management and clinical support interventions.

What the study has added to the body of knowledge

- Three to four time-controlled surveys per day were acceptable to study participants.

- Participants were willing to respond to a brief survey in the moment if the length and timing were acceptable.

- Medication reminders and location-based triggers were welcomed and contributed significantly to medication adherence.

- Goal setting, motivational messages and problem solving were welcome components to the intervention according to participants.

- Although they were comfortable using a mobile phone to send and receive intervention messages, privacy was vital for people living with HIV who participated in this study.

- Key points regarding privacy protection include nondescript wording, control over location tracing, anonymized data for sharing and assurance of password protection.

- Participants in this study reported limited desire to interact with other participants.

- Customization of the reminders and messages were desired to reduce user burden and increase attractiveness and acceptability of the mobile platform.

Table 1

Mobile phone themes and features to facilitate ecological momentary intervention that emerged during focus groups with persons living with HIV (PLH) and mothers.[a]

Feature	PLH (n = 29)	Mothers (n = 24)
Completing surveys during the day	Considered acceptable, given incentives and ability to customize	Considered attractive to some, acceptable to most, especially with the ability to elaborate or reflect on events at the end of the day
Completing surveys in the moment	Considered acceptable, given incentives, ability to customize, purpose, and privacy sensitivity	Attractive to some, especially with access to a 'button' for quick recording of an event
Reminders	Important for medication adherence	Customization important, random reminders problematic
Goal setting/monitoring	Potentially valuable for medication adherence, reducing risky sexual behavior, drug use, and stress	Opinions differed on content, some wanted in relation to food, others wanted motivational messaging
Feedback	Less opinionated on format	Did not want simple data summary
Password protection	Attractive and necessary, particularly for drug use and sexual behaviors	Not important, some considered it not attractive as they felt it increased user burden
Image capture	Context dependent but useful tangible examples were difficult to imagine	Attractive, as long as constrained to capture of food
Access to data	Less opinionated	Through phone
Stress button	Not discussed	Suggested by mothers
Peer support	Attractive to a few	Considered acceptable, especially with the ability to customize reminder timing
Data sharing	Attractive to some, especially if anonymized; does depend on question content	Attractive to some, especially with control over which data will be shared (e.g., a button at the bottom of a screen that keeps responses private)

[a]Themes were generally classified into one of four categories to identify 'highest' level of interest for each feature: attractive, acceptable, not acceptable, not important. participant, or anticipated times and locations of risk potential (e.g., weekend evenings in clubs or bars).