

mHealth Consumer Apps The Case for User-Centered Design

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mHealth applications, or “apps” as they are more commonly known, offer the opportunity to improve healthcare delivery and clinical outcomes. The ability to monitor patients remotely can enable patient risk-factor management and improve treatment compliance, thus allowing early detection of medical complications and ultimately preventing unnecessary hospitalizations.¹

In addition to enhancing the delivery of care, one of the most significant opportunities that mHealth offers is in the consumer health domain, allowing patients to actively engage in and self manage their condition.² Mobile phones also allow for the design of timely interventions based on user behavior. mHealth-mediated behavioral interventions can produce cognitive, behavioral, emotional, and social health-oriented responses.² As such, mHealth apps are particularly appropriate for problems where treatments depend on patient behavioral change, such as those related to smoking, obesity, diabetes, and other chronic conditions.

Despite the many potential benefits of mHealth apps, pilot studies aimed at evaluating the effectiveness of mHealth interventions have yielded mixed results.³⁻⁵ Furthermore, a quarter of all app downloads are used only once.⁶ Consumers often do not return to applications

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that do not immediately engage them, therefore undermining the intervention’s potential effectiveness. Regrettably, there is no simple formula for designing engaging and effective mHealth apps.^{7,8}

Currently, many electronic health (eHealth) and mHealth interventions are designed on the basis of existing healthcare system constructs and may not be as effective as those that involve end users in the design process.⁹ Moreover, designers often base their designs on assumptions that are not validated with primary user input. The resulting systems may lack key features, and subsequent evaluations of the effectiveness of the interventions may be compromised.¹⁰

For this reason, we employ the user-centered design (UCD) process—an evidence-based approach informed by the needs and understanding of a specific end-user group. In our experience, designing mHealth and other apps,⁵ UCD plays a key role in achieving user engagement, thus improving the likelihood of the intervention’s effectiveness. The World Health Organization agrees, and advises that user evaluation be incorporated into the mHealth project lifecycle to ensure effective outcomes.⁷

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Engaging Users to Produce Effective mHealth Apps

User-centered design, as the name implies, involves consideration of the user at every stage of the design process. Iterative cycles of prototyping and user testing lead to improved ease of use and adoption by end users.¹¹ In the context of mHealth-mediated care, UCD represents a systematic process that is key to ensuring applications remain patient-focused.

As outlined in Figure 1, the UCD process begins at the concept generation stage. Once users have been identified, a thorough investigation of their needs is conducted in order to understand the intended use and goal of the mHealth application. Human factors research techniques such as in-context field studies (ethnography), focus groups, and one-on-one interviews contribute to this user needs assessment. Other important factors to consider may include the environment in which the application will be used, the social or organizational culture of the user group, potential cognitive biases, and the group's preferred communication style.

After this initial investigation of user needs is complete, the next step is to translate these into a set of functional requirements and design guidelines. There are several practices used to accomplish this transformation. One effective technique is bottom-up thematic analysis^{10,12-14}—an iterative exploratory process of analysis of user data transcripts from interviews or focus group discussions, where text segments are coded for potential themes. This process is also known as open coding.¹⁵

As the coding framework develops, transcripts

are re-analyzed in light of new or emerging themes. Major themes that are relevant to the software system goals are thus derived. These concrete themes are then used to inform the app development through the derivation of specific design principles. The design principles are used to focus the development team so as not to deviate from the UCD process.¹⁰

Initial prototypes can be simple sketches and wireframes that help to elicit feedback and lead to a deeper understanding of the intended goal of the application. As the design cycle progresses, designs are evaluated and refined iteratively with users, by way of walkthroughs and usability testing.

During a walkthrough, participants are assisted by a facilitator through the process of using an application,¹⁶ and encouraged to think aloud and provide feedback on the difficulties they experience with the proposed workflow. This feedback ensures that the performance of the application matches the user requirements. Once a functional prototype is available, usability testing—which provides a more objective way of evaluating the design than with walkthroughs—can be conducted.

During a usability test, a representative user works independently in a controlled environment through a set of scenarios representing typical usage of the app, while simultaneously thinking aloud.^{17,18} Observers take notes of the participant's behaviors, comments, and issues,¹⁹ which help to uncover hidden functional and interface design flaws.²⁰

Usability testing is considered to be “a cornerstone of best practices for the design of medical devices.”¹⁷ Alternatively, a field study

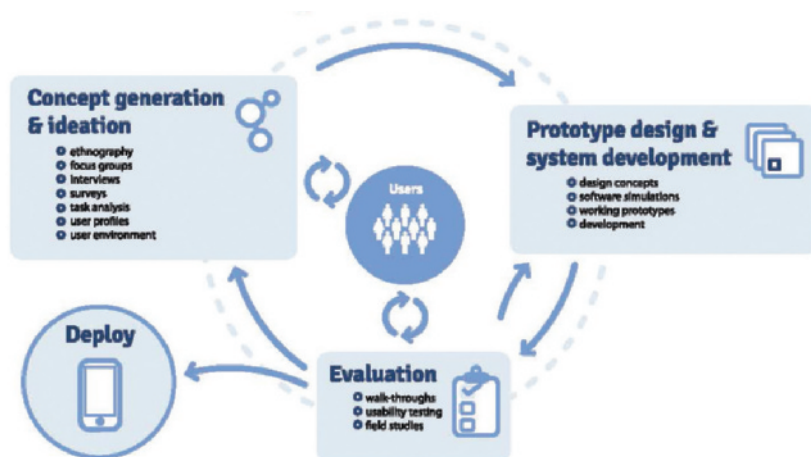


Figure 1. User-Centered Design Process

may be conducted where usability data is collected in the users' natural environment, such as in people's homes or places of work, as they interact with the product.²¹ This can be done through observations, or by means of remote data collection techniques such as automated usage data transfer or video.

It should be noted that the user-centered design process can vary in degree of complexity. During the early stages of design, the evaluation process can be simple and include tests of users performing high-level tasks using low-fidelity prototypes. In later design stages, users can be asked to perform realistic tasks with working prototypes.

Usability feedback should ideally be elicited early in the design process, so that potential use-related issues can be addressed early in the development life cycle. The following three app development processes illustrate the importance of this point.

Case Studies of User-Centered Design In mHealth

1. A Diabetes Self-Management App for Adolescents

One of the most prevalent chronic conditions requiring intensive self-management is type 1 diabetes. Among those affected by the condition, adolescents are a particularly challenging population for effecting a positive health behavioral change with respect to self-management. Global studies have repeatedly demonstrated that therapeutic targets for glycemic control are not met by adolescents.²²

Recognizing the appeal that smartphone technology presents to this specific user group, we utilized UCD to design and develop an mHealth app to keep these young patients more consistently engaged in their self-care. We invited adolescents with type 1 diabetes, their families, and care providers to help us design, develop, and evaluate a home-based diabetes telemanagement app that we named Bant, after the co-discoverer of insulin, Frederick Banting.

The early design stage entailed conducting qualitative interviews with the adolescents and their parents, as well as focus group sessions with their clinical teams. Design requirements were derived through a thematic analysis of the interview transcripts. One of the themes that emerged was the need for fast and discrete transactions so that adolescents can avoid social



- Agenda-like BG measurement viewer with goal range and electronic logbook
- bant settings which adjust goal range, customize measurement contexts, and add reminders
- Peer-support via micro-blogging
- Alert wizard to assist in trend analysis of consecutive out-of-range measurements
- Log of experience points earned to be exchanged for gifts redeemed through iTunes of the App Store

User-centered design features in Bant, a diabetes self-management app for adolescents.

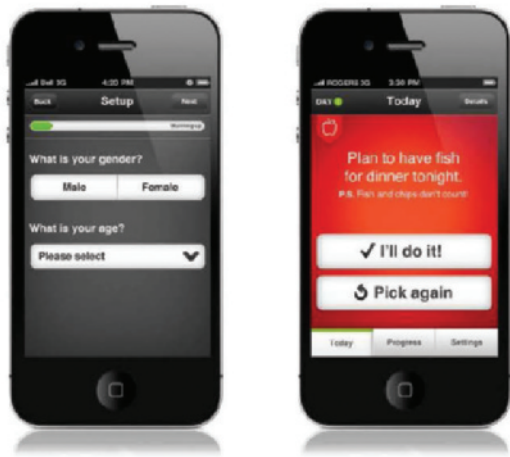


The Bant system includes an iPhone and a LifeScan glucometer with a Bluetooth adapter for automated data transfers to the app.

embarrassments such as having to test their blood glucose level at lunchtime.

Such social factors are independent of proper diabetes self-management functions, but are key factors in whether an app will actually be adopted by users in this demographic group. It would have been difficult to derive this requirement without having had user involvement in the design process.

Another requirement that was identified was the need for sustained user engagement with the app through rewards and incentives. Thus, rewards in the form of music and apps through the iTunes store were introduced as part of Bant. Next, paper mock-ups were shown to potential users and their feedback was solicited



- 30 day design for achievable, short-term results
- Reminders that include users' personal motivation
- Variety of specific and actionable daily tips/activities
- Connect with community that challenges and supports

User-centered design features in <30 Days, a heart health promotion app.

so that the daily blood glucose measurement trends could be presented in the most intuitive and straightforward manner.

To evaluate the app, adolescents were supplied with an iPhone with Bant installed, and a LifeScan glucometer with a Bluetooth adapter for automated transfers of blood glucose readings to the app. Instead of conducting a lab usability test, we decided that a field study where data is collected in the users' natural environment would provide more meaningful data for the adolescent user group.

After using Bant for 12 weeks, adolescent users reported high levels of satisfaction with the app: 88% stated that they would continue to use it. They also provided feedback regarding the ease of use of each section of the app, their general thoughts about it, and suggestions for improvement, which the development team used to further enhance the app.

A comparison of behavior in the 12 weeks before adolescents began using Bant and the 12 weeks after revealed evidence of clear behavioral change. The average daily frequency of blood glucose measurements increased by 49.6% (from 2.4 to 3.6 measurements per day).²³ Although the pilot was limited to a small, single-site convenience sample with no control group, ongoing evaluation iterations combined with a randomized controlled trial will allow us to generalize the findings and determine the precise efficacy of the intervention.

In summary, the UCD approach facilitated the identification of critical end-user requirements that ultimately resulted in eliciting positive health behavior from a population that is difficult to engage in self-management. These positive results were achieved with minimal intervention by care providers, and

A comparison of behavior in the 12 weeks before adolescents began using Bant and the 12 weeks after revealed evidence of clear behavioral change.

provide further evidence that patient self-care is achievable with minimum dependency on the healthcare system.

2. A Heart Health Promotion App

Heart disease and stroke remain the leading cause of death and disability worldwide.²⁴ Online interventions currently exist to help consumers address their heart and stroke risk factors, but these are often too clinically focused, and inaccessible to those who are not naturally heart-health conscious. As such, the Heart and Stroke Foundation of Canada engaged our team to design a mobile application, named <30 Days, to empower consumers to address potential risk factors in their lifestyle, and ultimately manage their heart health.

Findings from existing literature and responses from user surveys were employed to build an initial mobile-based interactive prototype, which was then usability tested with a sample of 15 end users. Three iterations of prototype design and usability testing were conducted, with concurrent integration of visual designs that focused on user experience as well as the language and tone of design elements and written content.

Users of the <30 Days app were given a choice between three possible health 'coaches': assertive, supportive, or fun. The theme that emerged from user feedback was that a fun or light tone would be most engaging.

This finding was translated into a user requirement and incorporated into the app's user interface and content. As a result, the language throughout the app was kept informal, brief, and accessible, and the design theme was bright and playful.

Following each iteration of usability testing, we asked users in a post-test questionnaire if they thought the app would help them improve their health. Ninety-three percent of respondents either 'agreed' or 'strongly agreed' to the question.

The development of this mobile app is still underway, but these early results demonstrate the importance of a multidisciplinary approach (human factors, design, medicine, and public health), the inclusion of end users, and the employment of UCD methodologies in creating an intuitive, engaging, and effective mHealth application.

3. An Asthma Self-Management App

Asthma is one of the most common chronic diseases in the world, with approximately 300 million people affected by the disease.²⁵ It is estimated that asthma accounts for 1 in every 250 deaths worldwide, many of which are preventable, due in part to suboptimal long-term medical care.²⁵

The 2011 Global Strategy for Asthma Management and Prevention report identifies self-management as a key element in maintaining asthma control for better health outcomes.²⁶ Therefore, our team set out to develop a web-based and mobile

application in conjunction with the Ontario Lung Association to empower consumers and caregivers to proactively self manage their asthma between clinic visits.

To inform the initial design and development of the asthma mobile self-management system, we conducted interviews with patients to understand their specific needs and requirements for managing asthma on a daily basis. These interviews helped us investigate:

- How patients currently self-manage their asthma
- Whether patients felt there was a need for the proposed application
- The type of information the app should provide
- Any factors that may affect the effective uptake of the app

One interesting outcome derived from the initial interviews with patients was that the fun tone adopted for the <30 Days app was not well received by the asthma patient user group. They felt that the fun content or language belied the seriousness of their chronic disease condition.

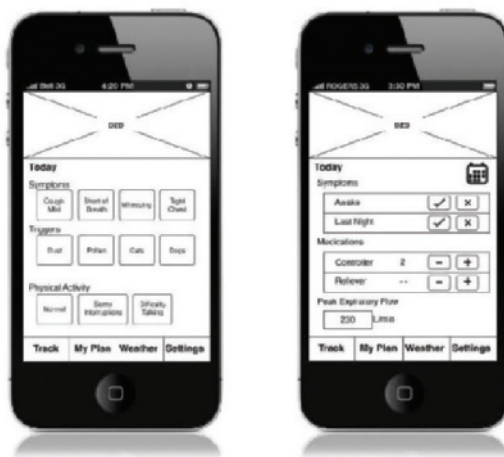
In the development process for a typical mHealth app, this finding may not have become apparent until after the application was released to the public, further reinforcing the need for user feedback throughout the design and development stages.

As care providers will also be remote users of this app, we validated the patient workflow with clinicians and subject matter experts. Prototypes of this app are now being developed, and will be refined through feedback gathered during usability testing. An example of an early wireframe software simulation is shown above.

The design and evaluation process will be repeated for three iterations as the prototypes gain higher fidelity. The engagement of patients with asthma to provide objective feedback throughout development, and not just be passive recipients of the intervention, will be key to end-user adoption of the app, and ultimately to its effectiveness in producing sustained behavioral change.

Conclusion

From our experience, when users are engaged throughout the app development process, a number of key system requirements can be identified that could otherwise be entirely missed.



- Intuitive symptom, peak flow, trigger and medication tracking
- Control zone calculator with personalized next steps
- Current weather and air quality conditions tailored to user's location
- Trending feature to encourage better self-management

User-centered design features in early wireframe prototypes of the Breathe app.

The implementation of a UCD process in the development of mHealth tools is critical in ensuring user engagement, and consequently app effectiveness in terms of sustained behavioral change in the users of the app. However, current industry practice often views usability testing as optional, expensive, and prone to delay project timelines.

In fact, the U.S. Food and Drug Administration (FDA) recently mandated the utilization of human factors design and evaluation practices for a wide range of medical technologies.

While the utilization of UCD is not always common in the domain of mHealth, its benefits have been recognized in healthcare systems design in recent years. Guidelines and standards for medical device design and usability testing have been published extensively.^{16,17,27-31} At present, medical devices, software, and other technologies go through a rigorous process of user needs analysis, iterative design cycles, and usability evaluations.

In fact, the U.S. Food and Drug Administration (FDA) recently mandated the utilization of human factors design and evaluation practices for a wide range of medical technologies.³² Furthermore, the Agency for Healthcare Research and Quality has recommended that

usability become part of the certification test for electronic health records to ensure safety and effectiveness of system integration.³³

Continued research on the effectiveness of user-centered design in the domain of mHealth and its ability to foster behavioral change is needed to establish stronger evidence, and will be an important contribution to the healthcare industry. Recognizing the advantages of a UCD approach and the unrealized potential of mHealth as a means for enhancing self-care, we recommend that development efforts implement a UCD process from the early stages of design. We believe that only then will mHealth apps meet users' expectations, lead to improved self-care, and ultimately improve user health outcomes. ■

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