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Design Considerations for Mobile Health Applications Targeting Older Adults

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Abstract

Mobile technologies are becoming ubiquitous in the world, changing the way we communicate and provide patient care and services. Some of the most compelling benefits of mobile technologies are in the areas of disease prevention, health management, and care delivery. For all the advances that are occurring in mobile health, its full potential for older adults is only starting to emerge. Yet, existing mobile health applications have design flaws that may limit usability by older adults. The aim of this paper is to review barriers and identify knowledge gaps where more research is needed to improve the accessibility of mobile health use in aging populations. The same observations might apply to those who are not elderly, including individuals suffering from severe mental or medical illnesses.

Keywords

Design considerations; mHealth; mobile health; mobile technology; older adults

The World Health Organization (WHO) defines mobile health (mHealth) as the delivery of medical practice by mobile devices, including smartphones, tablets, or wearable monitoring devices [1]. mHealth has many functions including: facilitating medication management through alerts and logs, providing self-care advice to patients, supporting self- and clinician-monitoring of biometrics (e.g., heart rate, blood pressure, activity), facilitating patient-provider communication, or educating patients on disease outcomes [2, 3]. With the ubiquity of mobile devices and internet access, the scope and availability of mHealth have markedly increased in recent years. There are estimated to be over 250,000 mHealth applications currently available to consumers [4]. While the availability of mHealth continues to increase, mHealth research is still in the relatively early stages [5]. Notably, these studies generally exclude adults 65 and older [6, 7]. Such a knowledge gap may greatly reduce the efficacy of mHealth applications for the elderly populations.

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Since 2013, the percentage of U.S. older adults ages 65 and up who own a smartphone has risen from 18% to 42% [8]. Similarly, internet usage in older adult has increased rapidly over the last 5 years, with almost two-thirds of older adults reporting internet usage in 2016 [8]. While this group is more digitally connected than ever, older adults consistently have lower rates of technology adoption than the general public [8]. Numerous studies report that adults over the age of 65 use fewer new technologies and use them less frequently than younger adults [9]. Similarly, the actual usage and adoption of mHealth remains low and inconsistent in this population [10]. An early study found that some of the primary reasons that older adults do not use technology include limited access to internet, cost, and lack of knowledge [11]. Other researchers found that although older adults were eager to learn how to use technologies, they also perceived that they might have difficulty learning to use technologies and that they would need more time to learn them than would younger adults [12]. A lack of experience with technology might be an obstacle to the use of mHealth by older adults. Older adults did not grow up in the age of technology and were not required to learn to use the computer as part of their education. It was reported that older adults with no computer experience are more likely to report concern and fear of using technology [13]. Similarly, researchers found that age was negatively linked to technology knowledge and interest and positively linked to technology anxiety [14].

mHealth applications offer a number of benefits to older adults. They can enhance the lives of older adults by allowing them to live independently longer [15]. In addition, they can provide an opportunity to alleviate the cost and burden for older adults to engage in health care services [16]. Overall, mHealth applications align well with the increasing interest of older adults to integrate technologies into their own health care, particularly those who live in remote locations, far away from local health facilities, or in areas with shortages of medical professionals. However, such technological advances also pose a great challenge to the elderly populations [17]. Cognitive impairment is one of the most common health problems for adults aged 65 years or above [18]. It is estimated that the prevalence of cognitive impairment is higher than 40% among older adults aged 80 years and above [19, 20]. Cognitive impairment is also a common feature for individuals with significant mental problems, such as schizophrenia [21] and mood disorders [22]. However, the actual age patterns of mHealth use for different patient populations have not been well documented.

While much remains unknown regarding factors that affect older adults' engagement in mHealth, usability studies show that existing mHealth applications do not meet the specific needs and expectations of older adults [23]. Similarly, an integrative review also commented that even though there are a wide range of telehealth technologies available to chronically ill patients, not all of those technologies may be appropriate for the elderly populations [24]. Overall, previous literature identified several key categories of barriers to mHealth use by older adults [25–27]: 1) cognitive and physical declines; 2) perceptual changes (vision and audition); as well as 3) reduced motivation. The purpose of this paper is to provide a summary report, based on the results of current literature, to identify research gaps and needs to establish efficacy of mHealth designs targeting older adults. The same observations might also apply to other populations, including those who are mentally or medically ill.

BARRIERS TO THE USE OF MHEALTH IN OLDER ADULTS

Cognitive and physical barriers

Many age-related cognitive changes, including reduced attention, processing speed, executive function, visuomotor skills, and memory, may all negatively influence mHealth use [28–31]. A recent case-study reported that cognitive barriers (e.g., declines in attention and thinking skills) were the second largest category of aging barriers negatively affecting usability of mHealth app [32]. In the study, users age 50 or above had difficulty returning to previously shown information in the app, determining where to find information, and understanding app’s functionalities. Within this context, another study showed that senior mobile phone users, even after more than one year of experience, still had trouble understanding basic operations and functions [33].

In addition, physical impairments can make holding a device in one’s hand uncomfortable [29, 34]. Common age-related illnesses that may negatively influence mHealth use include arthritis, slower movement and reflexes, stiffer muscles and joints, hand tremor, and poor balance [24, 28, 35]. More than 75% of the American population aged 65 or older have difficulty with physical functioning [36], presenting challenges in mHealth implementation for elderly populations [37].

Considerations for age-related cognitive and physical decline

Recent design guidelines for mobile interfaces acknowledge the relevance of cognitive function to interacting with mobile services and suggest that cognitive load should be minimized, such as by a clear navigational structure and supporting an interface that matches the needs of older adults [31, 33]. Three publications reported that a consistent interface is an important feature when designing technology for older adults [30, 38, 39]. For example, consistent use in language or terminology (e.g., use of the words “previous” or “back” to instruct an individual to move backwards on a screen) might reduce confusion among older adults who are not familiar with technology terms [38]. Similarly, inconsistencies in the processes for entering and saving information in the applications, such as interchangeable use of the terms “done” and “finish” may also increase user confusion, leading to unsuccessful attempts to enter data [30]. To minimize user confusion, some recommend that the colors, sizes, and language used for labeling buttons and icons be standardized [39]. However, additional works are needed to evaluate these features in older adults across cognitive spectrums and establish empirical guidelines to provide a consistent interface for diverse elderly populations.

Changes in executive functioning can cause difficulty with filtering irrelevant information and learning how to use technology [40]. Working memory may also become easily overloaded with age, interfering with technology use [41]. A recent review study reported that even though older adults are interested in using smartphones and tablets for obtaining health information [2], over 75% indicates that they would need help to walk them through the process of learning how to use the new device [42]. Similarly, other researchers noted that majority of elderly participants expressed interest in mHealth use if they were provided with adequate training [43]. A recent focus group study suggest that simple step-by-step

tutorials may help maximize a sense of mastery in older adults [44]. However, further investigation is necessary before any definite conclusion can be drawn. Specifically, it remains unclear whether a step-by-step walkthrough will increase or decrease the cognitive burden for senior users. Additional works are required to determine to what degree of guidance fits the greater need of senior users experiencing cognitive decline. On the other hand, while self-paced designs seem to be an appropriate option for some senior users given their cognitive decline, investigation on this topic are largely understudied. Understanding timing of tutorials or implementation of self-paced design could help maximize efficiency and flexibility.

A qualitative analysis of a focus group study reported simplicity as one of the key considerations in designing technology-based tools for older adults [45]. Similarly, two publications mention that user-friendliness is a facilitating factor of mHealth use by older adults [43, 46]. As mentioned by the authors, older adults are more likely to keep using mHealth application if it is simple and works easily. For instance, data entry involving clicking through multiple options may reduce user motivation. To minimize cognitive demands of mHealth use, some suggested using fewer than three steps for entering data and providing an auto-save function for finalizing entries [39]. While simple instructions with fewer buttons and a minimalist design are preferable for seniors [44], additional research is needed to guide design decisions in the appropriate balance between features and simplicity of mHealth applications for older adults.

A home screen containing many icons requiring users to scroll to view all of the icons was described as a poor design for older adults [39]. To ensure all key functions are visible on the home screen without the need to scroll, some researchers recommend the number of key functions available on the home screen be limited to 12 or fewer for tablets and 6 or fewer for smartphones [39]. The researchers also suggest information and questions be split up into two separate pages to simplify intra-app navigation and eliminate scrolling. However, it is unclear if removal of scroll bars will increase acceptability of mHealth among older adults.

Prior researchers noting the importance of specific user interface designs for older adults report that use of large targets and characters should be considered [31]. In addition, the researchers emphasized the importance of using a proper visual display with objects, such as buttons, that older adults can differentiate from other visual display features. Subsequent investigators further support the notion that user interface design elements such as font size and buttons should be modified to aid the senior user population [32]. Specifically, interactive elements are recommended be large enough to allow for less precise motor control [47]. A guide for app developers recommends each interactive element have a focusable area or touch target size of at least 48×48 dp [35]. A recent article suggests developers using large round or square buttons/icons of at least 15 mm in diameter rather than narrow or rectangular buttons, to ensure they are usable by older adults with poor fine motor control [39]. The article also suggests more space between buttons/icons within an application to reduce errors with button selection [39]. Future research is needed to determine the effectiveness of these suggestions on improving mHealth utilization in older adults.

Perceptual barriers (vision and audition)

Globally, the majority of individuals with vision impairment are over the age of 50 years [48]. A visual impairment, such as macular degeneration, makes viewing a digital screen difficult [49]. Age-related visual changes include reduced ability to resolve detail, focus on close objects, discriminate between colors (i.e., violet, blues, and greens), detect contrast, as well as adapt to darker conditions and glare [25, 26, 28, 31, 34, 35]. A study assessing mHealth usability problems by older adults reported that senior users oversaw important icons or feedback messages and had trouble reading small-font texts in apps [32]. In the study, 90% of the participants wore a visual aid such as glasses during the testing of mHealth apps, but nonetheless experienced usability issues due to perception barriers. In addition, hearing abilities decline with age [50], which also impacts their overall satisfaction on mHealth use [51]. Older adults with moderate to severe hearing impairments showed lower internet use compared to those with no hearing impairments [50].

Considerations for aged-related perceptual changes

Previous research made a number of evidenced-based recommendations for how to design patient websites to make them easier for older adults to use, including organizing information in a way that matches with older adults' expectations, simplifying website navigation with shallow menus and quick links, and using fonts and formats that are easy for older adults to read [52]. However, many of the recommendations apply more generally to making websites easier for elderly patients. A systematic review of 57 telehealth studies concluded that reading materials must be explicit and clear for older adults with reduced vision [37]. Given decreased visual acuity in older adults, researchers suggested that size of icons and texts on the mobile app be increased [43]. Some researchers recommend zoom features (e.g., a magnifier) be implemented to allow images and text to be resized [38]. The American Printing House for the Blind recommends use of a sans serif typeface (see Fig. 1). Serifs are small lines or stroke regularly attached to the end of a larger stroke in a letter or symbol within a particular font or family of fonts [53]. In addition, headings and subheadings are recommended to be larger and bolder than the regular text and left-only justification for a clear organizational pattern [53]. However, more studies are needed to evaluate if these recommendations remain relevant in mHealth applications targeting older adults.

According to the American Printing House for the Blind, black print on white, ivory, cream, or yellow with a dull finish is recommended to avoid glare [53]. Some recommend using high-contrast combinations of bold colors rather than pale or fluorescent colors to accommodate age-related declines in color vision [39]. The World Wide Web Consortium recommends using a text-to-background contrast ratio of at least 4.5:1 for small text and at least 3:1 for text larger than 18-point regular font [54]. Online tools, such as WebAIM Contrast Checker and MSF&W color contrast ratio calculator, provide easy methods for measuring text-to-background contrast ratio. The choice of color and contrast could be evaluated in future studies to verify older adults' preferences for color and contrast in mHealth applications.

A recent study exploring facilitators of mHealth use in older adults reveals that senior users appreciate audio feedback [43]. Similarly, another study exploring older adults' preference regarding technology-based applications found that participants favored the use of voice navigation because of their vision issues [55]. Previous research has shown the value of audio-based cues for older adults who use technologies [56]. A voice assistant, such as a screen reader, may facilitate older adults with vision impairment in completing tasks or navigate the device. An app developer guide by google recommends the use of "touch interface screen readers" to allow users run their finger over the screen to hear the on-screen text and elements (such as buttons) directly underneath [57]. Most guidelines for communicating with older adults emphasize amplifying and augmenting speech to compensate for hearing impairment [58]. "Clear speech" recommendations focus on speaking slowly and loudly, inserting pauses between phrases and sentences, stressing key words, enunciating each word precisely, and minimizing background noise [59]. While it is well known that the use of audio-based cues can improve acceptability of mHealth applications in older adults, further studies are required to determine more precisely when and how to use the technique most effectively.

Motivational barriers

One of the most frequently mentioned barriers to technology use in older adults is motivation [60–68]. According to the publications reviewed, a lack of motivation also contributes to adherence to mHealth use in elderly populations. At the same time, when facilitating factors were studied, many report that strong motivation with adequate support and feedback are important for the promotion and continuity of mHealth use in older adults [60–62].

Considerations to increase motivation in using mHealth applications

According to three publications, rewards are important as a mechanism to enhance mHealth use by older adults [46, 63, 69]. The rewards could be opportunities to enhance health care interactions, increased peer communication and support, greater access to medical information, and identification of meaningful information [69]. A survey study revealed that close to 95% of elderly participants expressed preferences for technologies designed to support healthy aging, including physical and cognitive health, self-manage existing conditions, and track changes in cognitive changes over time [70]. The survey also revealed that most participants reported interest in technologies designed to specifically assess mood-related concerns and changes. When asked about technology-based intervention, there was an overwhelming interest in technologies designed to improve individual risk factors for cognitive loss and dementia. In addition, utilization of performance-based reward is also recommended to boost users' engagement (e.g., sending a quick congratulatory message after completing a task) [71]. Additional research is needed to determine which reward options and reward strategy may translate into increase mHealth use in older adults.

In a systematic literature review, researchers mentioned lack of time or other priorities as one of the factors influencing the low use rate of mHealth in older adults [46]. In the review, researchers suggest developing an app that can be paused and the use can be readily resumed when the older adult has time. However, the review adds that mHealth use is a

challenge in senior users as older adults do not always have the proper skills to work with technology. A study on computer literacy in older adults reported that there was a negative relationship between computer self-efficacy and computer anxiety [72]. To keep senior users motivated, the Health Information Management and Systems Society guidelines for mHealth recommend that if a user make a mistake, the application may help to avoid it or provides a mechanism to recover from errors smoothly [73]. In line with the guideline, a recent study proposed using feedback messages in interfaces and suggest that these messages should not only inform users on their actions, but also provide the user options to recover from erroneous actions and return to previously retrieved information or action [32]. In addition, the study proposes using a clear video instruction on how to use an app to help older users register for an app, including help to return to the instruction during any point in an app's usage. However, future studies are needed to evaluate how to best provide support and feedback for senior mHealth users.

According to a Bloomberg report, cybercriminals steal almost \$40 billion from older adults in the United States every year [74]. A recent survey found that 67% of surveyed older adults have been the victim of an online scam or hack [75]. Many older adults are concerned with data privacy in their day-to-day usage of technology [44]. A recent focus-group study with adults aged 50 + found that the most common concerns raised about technologies centered around privacy [69]. For some participants in the study, concerns about security and privacy (e.g., who can access their data) appeared to outweigh potential benefits. While all participants expressed a desire to have increased access to their medical records, opinions varied as to who should be responsible for managing the medical information. Some researchers recommended using personalized privacy settings, where mHealth users can selectively share information with specific people or hide it from others [39]. Overall, more studies are necessary to identify how to educate users on protecting their information from being hacked and how to provide training to reduce older adult's concerns about data privacy and security.

Co-design is defined as “the voluntary or involuntary involvement of public service users in any of the design, management, delivery and/or evaluation of public services” [76]. In a co-design process, designers and users work together to identify problems and explore possible solutions to address user-related issues [77]. Co-design is an evolving approach that is increasingly used by healthcare organization to improve the care and well-being of end-users [78]. A systematic review seem to suggest that co-designed technologies have a positive impact on health outcomes, such as increased ability to manage a disease, better access to healthcare, reductions in medical errors or incidents, improved patient satisfaction, increase disease knowledge, and reductions in medical costs [79]. While the review recognizes an increasing interest to involve older adults in the co-design of technology, the researchers also comments that the co-design processes varied greatly in their methodology and intensity of older adult involvement. What remains unknown is whether the beneficial effects of co-design technologies are greater than those reported for non-co-designed technologies. There is also a need to standardize the definition of co-design to facilitate comparison across studies and identification of effective approaches.

CONCLUSION

mHealth applications are an innovative approach for the delivery of healthcare and health information outside of a physician's office. As older adults increasingly adopt mobile devices, there is a need to ensure that they can use mHealth applications effectively. In this paper, we reviewed a range of common barriers to mHealth adoption in older adults. We also identify research questions that might have an impact on improving mHealth use by older adults. While this paper focuses on design features that might improve the uptake of mHealth by older individuals, other facilitating factors such as improved health and economic status or improved familiarity in technology in the older population today were not discussed. However, this paper is not intended to give a complete and extensive overview of all the factors involved. Rather, the goal is to stimulate future investigation on this topic and support evidence-based designs for senior mHealth users. To date, there have been relatively few studies looking at barriers and resolution strategies to improve mHealth use by older adults. Our observations warrant future studies to provide evidence base for standard mHealth design guidelines.

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Fig. 1. Examples of font with serifs (A) and font without serifs (B)	
A.	Times New Roman; Garamond; Georgia
B.	Arial; Calibri; Verdana

Fig. 1. Examples of font with serifs (A) and font without serifs (B) A. Times New Roman; Garamond; Georgia B. Arial; Calibri; Verdana.