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Kate Dupuis

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Kate Dupuis * and Lia E. Tsotsos

Sheridan Centre for Elder Research, Sheridan College, 1430 Trafalgar Road, Oakville, ON L6H 2L1, Canada; lia.tsotsos@sheridancollege.ca

* Correspondence: kate.dupuis@sheridancollege.ca; Tel.: +1-905-845-9430 (ext. 4229)

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Abstract: The impact of an aging population on healthcare and the sustainability of our healthcare system are pressing issues in contemporary society. Technology has the potential to address these challenges, alleviating pressures on the healthcare system and empowering individuals to have greater control over monitoring their own health. Importantly, mobile devices such as smartphones and tablets can allow older adults to have "on the go" access to health-related information. This paper explores mobile health apps that enable older adults and those who care for them to track health-related factors such as body readings and medication adherence, and it serves as a review of the literature on the usability and acceptance of mobile health apps in an older population.

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1. Introduction

Worldwide, the older population is growing at unprecedented rates, with the number of individuals aged 65 years and above rapidly outpacing younger individuals aged 20 years and below [1], and there is no indication that this trend is slowing. In fact, the number of older individuals is projected to increase over 60 percent by 2030, to more than one billion people aged 65 years and older worldwide; this number will be equivalent to 12% of the world's population [1]. Given this sustained trend, innovative solutions to the specific challenges likely to be experienced by an aging population (e.g., housing, healthcare, transportation) must be developed.

2. Internet Use in Older Adults

The first baby boomers are now in their early 70s, and this generation is contributing to the rapid population aging. These individuals were the first to grow up with televisions in their homes, and they continue to embrace technological innovations at a rapid rate. Indeed, older adults are avid users of the internet, with 81% of those aged 65–74 and 50% of those aged 75 and older reporting use of the internet at least a few times a month in 2016, an increase of 16% and 15%, respectively, in just three years [2]. Among internet users aged 65 years and older, 70% use the internet on a typical day [3], and older adults are the fastest growing group online [2]. According to a report from the Advanced Communications Law and Policy Institute [4], the most common reasons for going online amongst those aged 65 years and older are to communicate with family and friends (75%), shop for products or services (58%), and to get information about healthcare and medical issues (53%). Similarly, in another study where older adults were asked about their online habits, almost half (47%) reported having searched for health information online [5].

2.1. Health-Related Information and Communication Technologies

The use of health-related information and communication technologies (ICT), including computerized devices, home computers, and the internet, may serve to provide cost-effective healthcare solutions for the older adult population [6]. While there has been an increase in the adoption of ICT over time, older adults remain somewhat resistant to the use of ICT, with specific barriers identified including (1) health status, with healthier older adults being more likely to adopt ICT and (2) marital status, with those individuals who had a partner being more likely to adopt ICT, perhaps due to the added support and the availability of someone else to help troubleshoot should an issue arise. The survey described above focused on personal computers; it may be that, with the advent of novel information and communication technologies including mobile phones and tablets, it is becoming increasingly easier for older adults to access health-related information.

2.2. Integrating Health Management with Aging in Place

As the older population grows, the ideal, and most cost-effective, solution is to have them remain in their own homes for as long as possible. Indeed, when surveyed, the majority of older adults report that remaining in their own homes is the ideal scenario [7]. Most older adults are achieving this goal of living in their own homes, with over 90% of those aged 65 years and older living in private dwellings [8]. Developing and implementing innovative ways for older adults to manage their health and well-being at home may help to support aging in place, with resulting savings to the health care system [9]. This is particularly relevant for the approximately one third of individuals aged 65 years and older who live alone [10], as living alone has been linked to poorer health outcomes (e.g., risk of falls, functional impairment, social isolation) [11]. Of course, when developing new products and procedures, it is necessary to consider what older adults actually want, need, and will likely use. However, technology does represent one promising means of influencing the health and well-being of this population and may be especially important for those older adults who remain alone in their own homes and are at an elevated risk of health issues [12].

2.3. Barriers to Technology Use in Older Adults

Although the acceptance and usage rates of technology are increasing in older adults, there remain significant barriers to the use of technology and technological innovations in this population. Indeed, a recent systematic review of the literature by Vassli and Farshchian [13] demonstrated numerous barriers, including privacy concerns, usability and ease of use, reliability, product costs, familiarity with and trust in the technology, and lack of training with the technology. Self-efficacy and feelings of anxiety related to the technology can have a significant influence on older adults' willingness to use a computer [14]. More specific to mobile devices, Vaportzis and colleagues [15] found that most older adults are eager to adopt new technology and learn how to use a tablet. However, as with the paper described above, these older adults also indicated that potential barriers to using a tablet included a lack of knowledge, confidence, and clear instructions for their use. Identifying these barriers is necessary to ensure that solutions to overcome them are being appropriately designed and implemented with older adults.

3. Chronic Health Conditions in Older Adults

The use of the internet to access information about health conditions and healthcare appears to be particularly relevant to older adults. This is likely due to the fact that chronic health conditions, defined as any health problem that persists over time and requires some degree of healthcare management [16], are so common in this population. More than 90% of individuals aged 65 years and older report one chronic health condition, and 70% report at least two conditions [17]. The five most common chronic diseases in older adults are hypertension, high cholesterol, arthritis, heart disease, and diabetes, affecting between 27% and 58% of those aged 65 and over [18]. Given the high prevalence

of these diseases, it is a public health imperative that we find new ways to best support the health and well-being of an older population.

Managing Chronic Conditions

The World Health Organization has identified that chronic conditions will be the leading cause of disability by 2020 [19]. Medical models have traditionally been centered around treating acute episodes of illnesses. However, highly prevalent health conditions such as those described above require extended and regular healthcare contact [19]. This shift from treating acute illnesses to chronic diseases highlights the importance of ongoing monitoring and treatment, with the goal of preventing complications [20]. Hospital-based interventions may not be sufficient for managing chronic disease. Instead, periodic visits to the hospital, combined with self-care at home, may be the most effective management tool [21]. Home management of chronic health conditions, with the need for intermittent, potentially at-a-distance, communication with healthcare professionals, provides a potentially important role for mobile technologies. Older adults are among the highest users of emergency rooms (ER), and have the highest rates of admission to hospital after a visit to the ER [22]. Given the high costs associated with ER visits and hospital admission, it is necessary to develop more efficient ways for older adults to track crucial health indicators and share them with healthcare professionals remotely, in an attempt to reduce expensive healthcare interventions.

4. Mobile Devices and Older Adults

In addition to the use of personal computers [23], many older adults are choosing to use mobile devices such as smartphones and tablets to access the internet [24]. Indeed, almost half of Americans aged 65 years and older own a smart phone [25], and tablet use by older Americans increased from 32% to 51% between 2011 and 2016 [26]. Usability, acceptance, and satisfaction ratings for tablets such as the iPad are quite high in older adults, and tablets may represent an effective way for older adults who have never used, or are uncomfortable using, a personal computer to go online [27]. For older smartphone users, more than half (62%) have used their devices to obtain information about a healthcare condition [25], which may reflect the need for older adults to have access to information quickly from any location (e.g., after leaving a doctor's office, at the pharmacy, or while travelling). As described above, the portability of these devices and the accompanying ease of accessing health-related information when outside of the home (e.g., when picking up a prescription at the drugstore or meeting with a physician), may make these devices an ideal way for older adults to access health-related information, and mobile devices have shown to be an accepted way of improving digital inclusion in an older population [28]. Older adults are also very accepting of technology that will help them to maintain independence and overall quality of life, which ties into the concepts of aging in place and management of chronic health conditions described above [29]. Interactions with mobile devices may play a key role in allowing older adults to access their health-related information and easily share it with family members and care providers.

5. Mobile Health (mHealth) and Older Adults

The field of merging healthcare and mobile information-communication technology devices such as smartphones and tablets (commonly known as Mobile health or mHealth; [30]) is growing rapidly, with over 7000 identified health mobile applications [31]. mHealth can provide helpful solutions for addressing existing barriers to treatment (e.g., long wait times for an appointment) and increasing access to services for older adults [32]. In addition, mHealth can serve to enhance quality of life for older adults and help them maintain their independence and age in place for longer [32]. Key interventions that have shown success include using devices to track health information, involve the healthcare team, and increase the accessibility of health information [33]. Thus, mHealth applications on a tablet or smartphone may represent a novel way for older adults to manage their healthcare needs and may play an important role in addressing the sustainability of our current healthcare systems.

A recent review of the available mHealth apps for older adults (*n* = 119) revealed that these are primarily used for management of current disease, and for physical illnesses rather than mental health conditions [34]. These apps have been tested with older adults for the management of chronic health conditions, such as diabetes [35]. Barriers to uptake and identified issues include user-friendliness, navigation, trust in own abilities, and concerns about the security of one's data. There is great inter-individual variability in the older adults using the apps, meaning that the apps must be able to be adapted for each user [35].

5.1. Studying Usability and Feasibility of Newly-Developed mHealth Apps

In order to determine how well an app will suit the needs of an older clientele, it is crucial to conduct pilot testing in order to observe how the target population interacts with the technology. One-to-one interviews or focus groups in which users are introduced to the technology and encouraged to engage with it, either on a smartphone or tablet, will provide the developer with the key feedback needed to modify and improve the product. Important aspects of app usage to consider are how easy it is to navigate through the various features, how the data are represented visually, how easily data can be communicated to other individuals (e.g., health care providers, family members), and whether older adults believe that they could feasibly integrate this technology into their everyday lives.

5.2. Ethical and Privacy Considerations

As part of the broader set of considerations when leveraging mHealth applications for older adults, one can consider how these may support the maintenance of dignity. There is some work to show that interactions with health-related technologies and applications can be dignity promoting, as they contribute to feelings of empowerment and control over their own health [36]. However, and as described above, it is also possible for older adults to have concerns about the ethics of storing data in and transmitting data from the mHealth apps and whether entered data will kept confidential. A review of the 600 most-commonly downloaded mHealth apps available for iOS and Android found that only 30.5% of the apps had available privacy policies [37]. This, of course, would make it very difficult for the user to find out more about how their personal health information is being stored and/or whether it is being shared. A systematic review of the literature indicated that, for the 20 most popular mHealth apps, only one allowed users to delete all of their personal information, and only two asked for user authentication before a user logged-in to the app [38]. Fifty percent of the apps stored data in a cloud that could risk consumers' data privacy, and the majority shared users' information to a third party or advertisers [38]. These findings indicate that app developers must work to ensure that data on their apps are more secure and to share information about data security with end users.

6. Conclusions

Technological advances are allowing for innovations in how chronic health conditions can be managed from the safety of one's home, and they represent a potential solution to rising healthcare costs for an older population. Older adults' acceptance of innovative technologies in their everyday lives is thought to be a key factor of success for governments, technology providers, and healthcare providers, among other groups supporting older adults [39]. The design and usability of a technology device or service can represent significant barriers to use [40], and even ancillary issues such as the effects of socio-economic status or education of older people can impact their use and adoption of technologies [41]. Furthermore, language abilities, access to the internet, and digital literacy are not always considered (or taken into account) when designing technologies [42], and these must be addressed to enhance the design of a novel product or app for an older population.

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