Using Smartphone Applications to Manage Chronic Conditions in Older Adults – A Review on Level of Evidence

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Abstract

Background: From health monitoring to health education and from behaviour change to falls sensing and health alerts to the simple pleasure of communication and connectedness, the mobile technologies (smartphone applications) are changing the lives of older adults. ***Objective:*** To examine current evidence of use of smartphones by older adults for health purposes (including communication, education, and health monitoring), and understand gaps and challenges in order to inform the design of future systems given the ubiquity of mobile phone technology. ***Methods:*** MEDLINE, CINAHL and Google scholar databases were searched from October 2016 to January 2017. Keywords used include 'smartphone apps', 'mobile phone', 'chronic disease', 'chronic condition', 'older adults' and 'elderly'. A total of 12 articles were selected for quality assessment and grading of evidence. ***Results:*** Twelve different articles were found and categorized into nine different clinical domains with specific health related interventions. Articles were focused on diabetes care (2 articles), followed by COPD (2 articles), heart disease (1 article), Alzheimer's/dementia Care (2 articles), osteoarthritis and pain management (1 article), fall prevention (1 article), colon cancer (1 article), palliative care (1 article), chronic kidney disease (1 article). Areas of interest studied included feasibility, acceptability, functionality and thereby determining their effectiveness. There were many different clinical domains; however, most of the studies were pilot studies. Current work in using mobile phones for older adult use are spread across a variety of clinical domains. Findings from different studies indicate that the use of mobile phone interventions has the potential to support successful management of chronic conditions and health behaviour change in older adults. ***Conclusion:*** Perceived benefits and willingness to use the smartphone apps are high; however, technical training and cost are main concerns. A common problem with elderly users was their reluctance to press buttons due to the fear of breaking something which has been resolved by touch screen technology of the smartphones. However, the advanced user clicked around the screen until he found what he was looking for, while the others spent a lot of time observing the screen and trying to determine the correct step. Promotion of user-friendly apps are expected especially for older adults having a diminished physical and cognitive abilities.

Keywords: Smartphone apps, mHealth, chronic disease, chronic condition, older adults.

Introduction:

With tremendous increase in amount of the elderly population, age related chronic health conditions of the elderly populations are showing increasing trends in different regions of the world[1]. Canada is not an exception to this phenomenon. The United Nations estimated that by 2050, the world population of older adults over 60 years will have doubled, while the age group over 80 will have tripled[2]. In 2013, seniors represented 15.3% of Canada's population; by 2056, one quarter of Canada's population will be over 65 years of age[3]. It is estimated that about one in four older adults have two or more chronic conditions and half of older adults ($\geq$ 65 years) have three or more (e.g. hypertension, heart disease, diabetes, arthritis, chronic obstructive pulmonary disease [COPD], stroke, dementia, etc.)[4-6]. To manage chronic conditions more effectively, researchers and policy makers have promoted patient and family-centered home-based health care, founded on interprofessional and community-based partnerships[7,8]. However, with the growth of innovation and addressing the demand, there are

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both internal and external drives to incorporate novel ideas for empowering older adults and their caregivers to manage their own conditions and to avail better communication among the circle of care[9,10].

New technologies and innovations have promised to make tasks faster, safer, and more efficient and effective. Technological innovations have already been used to bridge health related gaps and meet the challenges of unmet needs of populations in different areas of healthcare[11]. For an example, smartphones have become one of the most rapidly adopted technologies allowing for previously unimaginable opportunities for communication and access to information in modern life. The development of the different health related software programs "applications" or, more commonly called "apps" combines the communication functionalities of a mobile phone to create new and innovative uses in healthcare interventions. The use of such applications within the health care industry continues to grow, and it is estimated that the market for mobile health apps will grow to US$26 billion by 2017[12]. Smart devices have inherited the characteristics of cellular phones, and they are portable, pervasive, and becoming more and more affordable. In early 2016, the adoption rates of smartphones by older adults aged 60 to 69 years were 46% and 41%, respectively[13]. Older adults also have expanded the way they use smartphones, with health information seeking being the second most frequently executed task besides making phone calls[14]. With the growing older population, it is expected that more and more older adults will be interested in incorporating these smart devices into their chronic disease management. The growing appeal of mobile solutions for health promotion and healthcare delivery can be attributed in part to the accessibility of the technology, the level of personalization that technology enables, valuable location-based services, and timely access to information through data, voice, and/ or video media[15]. Several studies have been done with mobile phone interventions for managing chronic conditions such as hypertension, diabetes, COPD, Alzheimer's/dementia, and osteoarthritis. Findings from these studies indicate that the use of mobile phone interventions has the potential to support successful management of chronic conditions and health behavior change in the areas. Given the rapid growth of mobile phones (i.e. smartphone technologies), and its potential as a platform for improving the health of older adults, along with the projected growth of population, it is important to examine current evidence of use of smartphones by older adults for health purposes (including communication, education, and health monitoring), and understand gaps and challenges in order to inform the design of future systems given the ubiquity of mobile phone technology. Hence, a literature search was done to find answer to the following research question: *What is the level of evidence of the effectiveness of mobile phone based health interventions (more specifically smartphone applications – in short 'smartphone apps') in managing chronic conditions of older adults?*

Methods:
MEDLINE, CINAHL, and Google scholar databases were explored for literature search. Advanced search techniques terms were used like "smartphones", "older adults", "chronic disease" and related words including "mobile phone," "cell phone," "cellular phone," "smartphone apps" and "mobile apps" and "aged", "seniors", "chronic illness", "chronic condition". Search filters were also used like: age: 45-64 years and 65+ years; language: English; publication dates: From 2000 onwards. A total of 220 articles were identified. However, after removing the duplicates, 152 abstracts were screened. Among those 31 articles were downloaded for further assessment. Full-text articles were assessed for the eligibility that focused on smartphone use in health intervention in various chronic condition/diseases in older adults. Finally, only 12 articles have been selected finally, after exclusion of 19 articles (Fig.1). For chronic diseases, I searched for diabetes mellitus, cardiovascular diseases, chronic lung diseases, cancer, arthritis, chronic pain, risk of falls and the catch all term chronic disease. I also searched for cardiovascular diseases including hypertension, coronary artery disease, heart failure, and stroke. Chronic lung diseases included asthma and chronic obstructive pulmonary disease (COPD). Palliative care is also included as those patients were suffering from incurable chronic diseases. Appropriate subject headings (e.g., Medical Subject Headings-MeSH) were also used.

It is a review on the current situation of the community or public health approach, where mobile phone or mobile apps interventions are explored for the purposes of improving or managing the health or chronic conditions of
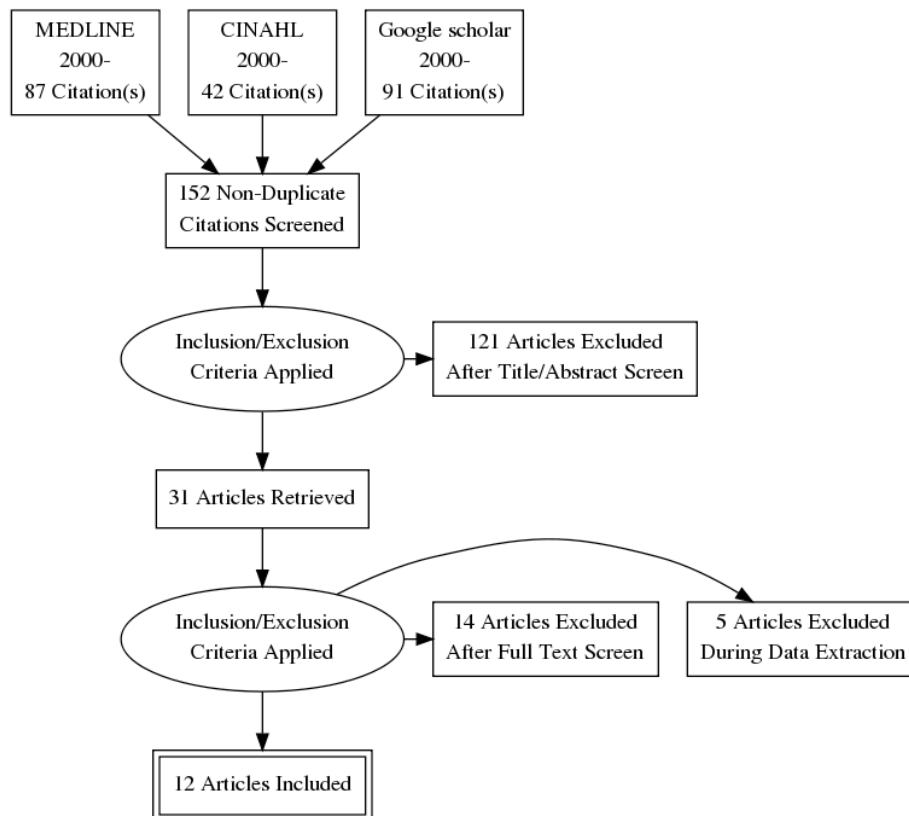
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Fig. 1. Prisma chart showing literature search strategy

older adults. Consequently, in order to be eligible for the review, the identified articles' projects needed to utilize a mobile phone/apps as an intervention, involve or explicitly target adult population of 60 years of age and older, and have an aim that emphasizes the mobile phone's use in health – more specifically in chronic disease condition e.g. diabetes, heart disease, asthma, osteoarthritis, dementia, cancer, pain etc. Within the initial search, abstracts were reviewed if they matched the aforementioned criteria. Once these articles were filtered, the remaining full text articles were analyzed for a more detailed review. Articles were eliminated if the focus of the project was on unrelated non-health aspects of a device or intervention, focused solely on the technology, or was not published in English. Articles that were unclear on how they fit into the scope of the criteria were also discarded. For each study included, a score was given on the level of evidence based on the Oxford Centre for evidence-based medicine framework[16]. This framework introduces levels to help assess the strength of evidence of study findings. The themes of the review were: smartphone use, chronic condition, functioning status, coping with medication and disease process, lifestyle modification, adherence to smartphone apps, and effectiveness of apps use

in health care. The work presented here was done as outlined by Arksey & O'Malley's framework[17] and steps suggested by Levac et al.[18]. All duplicate citations were removed. For articles that met the inclusion criteria at this level, or for those with insufficient information to determine if they met the criteria, the full-text versions have been retrieved for further assessment.

Results:

The initial searches on MEDLINE, CINAHL and Google scholar yielded 87, 42 and 91 respectively, for a total of 220 articles, before removing duplicates or filtering. Articles were eliminated based upon review of titles and abstracts, and finally 12 resulting articles from the filtered searches were categorized into 9 major domains of chronic conditions, which are going to be discussed in detail below:

1. Alzheimer's/dementia care: Mobile phones have been used for different purposes in dementia care, including memory enhancement and wandering safety. The use of mobile phones to track wandering patients via the global positioning system (GPS) chips has been explored by both Fauconau et al.[19] and Miskelly[20]. Miskelly[20] reported on being able to successfully and accurately locate 11 persons who have wandered, and the mobile phone acted as a reliable tracking device, showing greater than 90% successful location concordance with description given by the persons looking after the participants (Level of evidence: 4). Faucanau et al.[19] found attitudes, barriers, and feelings of usefulness of the tracking device, and reported on a case study with 1 caregiver and 1 subject, and reported on the subject's dissatisfaction with the aesthetic of the device, and the caregiver's usage difficulties (Level of evidence:4). However, both studies noted that compliance can be an issue, where it can be difficult to encourage or ensure that the patient carries the device so that they can

be located.

2. *Palliative care symptom management:* Effective palliative care requires the knowledge of, and changes in the symptoms of the patient, to minimize symptom distress and increase well-being. Consequently, mobile phones have the potential to remotely collect symptom data at regular intervals, which may not have been possible previously. McCall et al.[21] explored using a mobile phone platform for remote monitoring of symptoms via a patient's reported assessments (Level of evidence: 3). The study sought to assess the acceptability and usability of a mobile application via pre-post study questionnaires using 21 patients receiving palliative care and 9 health professionals. Automatic self-care advice was shown in response to patient input, and a healthcare provider remotely reviewed their symptoms daily. Both patients and healthcare providers reported that the tool was helpful or very helpful for symptom monitoring at baseline (Patients: 21/21, Providers: 9/9) and after the intervention (Patients: 9/13 (69%), Providers: Majority). The healthcare providers also felt the early warnings of symptom issues could permit timely interventions. Consequently, the pilot study successfully demonstrated feasibility, usability, and acceptability of the system.

3. *Congestive heart failure:* It disproportionately affects older adults, and those patients have a high rate of hospital readmission. The use of home monitoring through smartphones has shown promise for heart failure patients in reducing the duration of hospital stays and mortality rate. Scherr et al.[22] performed a randomized controlled trial with 120 participants to evaluate whether a mobile phone based telemonitoring platform could detect early symptoms of impending heart failure to prevent hospitalization (Level of evidence: 2).

4. *Chronic obstructive pulmonary disease (COPD):* Exercise training has been established to improve quality of life, including improvements in fatigue, emotions, and dyspnea for patients with COPD. Consequently, adherence to such a training program can improve patient quality of life and help with pulmonary rehabilitation. The feasibility of mobile phones for entering exercise and symptom data has been studied by Nguyen et al.[23], which found acceptable response rates (~83%) from patients using the program using 6 older adult patients with COPD (Level of evidence: 4). There have been further studies with more elaborate mobile phone interventions, including a mobile phone based exercise program by Nguyen et al.[24]. They compared a self-monitored group (n=8) that used the mobile phone program versus another group (n=9) that had ongoing reinforcement and symptom monitoring and found that the self-monitored group performed better than the coached group in a number of physical activity tests including increased total steps per day (p=0.04) and higher peak performance (p=0.002) (Level of evidence: 4).

5. *Diabetes Mellitus:* Since self-management of diabetes requires patient adherence to best practice recommendations (e.g. dietary management, glucose monitoring, physical activity, etc.), there has been an interest in increasing compliance with self-care advice. One method of increasing compliance is via reminders, which was explored by Durso et al.[25]. They reported that subjects had improved glycemic control and diabetes knowledge (3/7 (42%) subjects increased diabetes knowledge test scores) after using the system (Level of evidence: 3). Another important issue with diabetes is reducing the barriers to use of self-management tools, such as by increasing ease of use can also increase compliance with the tool. Lee et al.[26] investigated the use of a low power protocol, Zigbee, to transmit blood glucose and ECG data via mobile phone to a central server with 29 older adults. The data were successfully transmitted (78% blood glucose measurements successfully transmitted); thus, findings suggest that Zigbee (apps) may have a place in telemonitoring systems (Level of evidence: 3).

6. *Fall prevention:* Fall risk has also received attention, so that individuals at higher risk for falls can be monitored. Yamada et al.[27] assessed the viability of a smartphone-based dual tasking program as a measure to gauge fall risk via dual tasking lag when compared to single tasking. The subjects (n=318) were assayed while walking, but the results only weakly correlated with other physical performance tests previously validated with risk of fall. Further, the application could not accurately predict which subjects would eventually fall during the study period (Level of evidence: 3). However, the application did have advantages over traditional dual task tests, including portability, simplicity and greater access since the application could potentially be downloaded worldwide.

7. *Osteoarthritis and chronic pain:* Self-reported health information has been used as a way to provide more opportunities to measure health-related quality of life metrics. For osteoarthritis,

self-reported patient metrics have been developed, one of which is the Western Ontario and McMaster Universities Arthritis Index (WOMAC)[28]. Bellamy et al.[29] tested a version of the mobile WOMAC index (m-WOMAC) with older adult patients (n=12), who regarded the system as easy to use (Very easy: 11/12) and acceptable for use (Very confident in continued use: 11/12), with the index being transmitted successfully (Level of evidence: 4).

8. Colon cancer: Patients undergoing chemotherapy as a treatment may experience many undesirable side effects that can negatively affect their quality of life. Weaver et al.[30] sought to assess and analyze the feasibility of alert generation, patient satisfaction and acceptability, in their study that involved 6 subjects with colon cancer, and the mobile phone intervention issued an alert to clinical staff when moderate to severe symptoms were submitted, which allowed them to contact the patient and give them advice as needed. These systems also included a patient diary and automatic self-care advice, which did not overwhelm the patients. The systems were found to be feasible, with alerts being successfully acknowledged with 24/25 (96%) red alerts acknowledged by staff and the patients exhibiting high data entry compliance with the study showing 98% compliance for the diaries (Level of evidence: 2).

9. Chronic kidney disease: Adherence to medication is very essential for the patients of chronic kidney disease. Becker et al.[31] studied on 11688 smartphone users by tracking and collecting data with consent, to see whether smartphone technology increased adherence to drugs in different chronic kidney conditions (Level of evidence: 4). The study showed that smartphone apps helped to increase drug adherence in patients with chronic kidney conditions.

After critical thinking about quality – based on four core criteria of Neutrality, Consistency, Applicability, Truth Value – the articles were categorized by of strong evidence, medium, and weak. 5 were in strong category named Bellamy et al.[29], Miskelly[20], Nguyen et al.[23], Nguyen et al.[24], Yamada et al.[27]; 3 were of medium strength named Faucounau et al.[19], Scherr et al.[22], Weaver et al.[30]; while 4 are of weak evidence named Becker et al.[31], Durso et al.[25], Lee et al.[26], and McCall et al.[21]. It is important to not only look at the studies from individual disease states, but to look across broadly at the methods, outcomes, and processes of these studies to better understand the level of evidence currently available in aggregate for older adults. Analyzing the results of the studies indicates that some of the apps have been shown to be technologically very feasible, such as transmitting patient reported outcomes to a central server via the mobile device, or sending rule-based, patient specific feedback based on the data, while several other studies have shown high patient acceptability of mobile systems, along with patient satisfaction of the effectiveness of the system as well as improved clinical outcomes. However, many of these studies were pilot or feasibility studies with small sample sizes of older adults, and consequently need to be replicated with larger samples to generate more generalizable results and establish a higher confidence in the evidence.

Discussion:
Innovation in smartphone applications (smartphone apps) providing health information and sensing technologies and applications has the potential to improve well-being, both physical and mental, and to reduce the cost of health care among older adults in numerous ways[15,32]. From health monitoring and health education and behaviour change to falls sensing and health alerts to the simple pleasure of communication and connectedness, these mobile technologies are changing the lives of older adults. The ongoing studies on smartphone apps in fostering health behaviour change among older adults will require a multidisciplinary approach to consider proximal (e.g., physical activity, chronic disease management) and more patronization.

Most of the abovementioned studies identified were pilot or feasibility studies, resulting in a lack of overall generalizability. Even though these studies focused on older adults specifically, they often did not compare their findings against other age groups. There is a clear need for a stronger evidence base for usefulness and effectiveness of these smartphone apps or tools.

While technical success rates are important to ensure that the technology works, more studies need to be done with a link to clinical outcomes. A good example of this is Lee and colleagues' study[26] regarding how a health management system that included mobile phones affected glycemic control, which had a positive correlation between use of mobile device and clinical outcome. More investigation is needed to confidently establish whether smartphone apps/technologies can meaningfully improve an older adult's health and

well-being.

Another important issue is that these studies focused on a single condition or disease. Since majority of older adults have multiple chronic conditions[1], we need to explore how the use of smartphone technologies can help them manage and take control of their health in the context of managing multiple diseases simultaneously. Adding further complexity, as they age, older adults see decreases in dexterity, fine motor control, visual acuity and audio competence[1].

There are few limitations to this review that need to be acknowledged. Firstly, the review is based on research literature from mainly the health sciences via MEDLINE, CINAHL and Google scholar. There could be other interventions published in other outlets not included in these three databases, as well as commercially available tools evaluated in reports not published in a peer-reviewed article. In addition, the use of English only language search tends to have excluded those studies published in non-English languages that fell within the subject area.

Conclusion:

Current work in using mobile phones for older adult use are spread across a variety of clinical domains. While this work is promising, current studies are generally smaller feasibility studies, and thus future work is needed to establish more generalizable, stronger base of evidence for effectiveness of these interventions. Perceived benefits and willingness to use the technology are high; however, technical training and cost are main concerns. Besides, promotion of user-friendly apps is expected especially for older adults having a diminished physical and cognitive abilities. With the rapid growth of mobile phones, paralleled by the rapidly aging population, there exists a golden opportunity to utilize mobile phone technologies to help manage older adult health and to positively affect their quality of life and well-being.

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