

Design and Evaluation of a Mobile Health Application for Falls Management in the  
Elderly

by

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## **DEDICATION**

First to God without whom none of this will be possible.

To my parents and my siblings. Your never-ending love and support in helping me achieve my dreams is the reason I am here today.

And to my fiancé for your encouragement and for always being there.

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## **ABSTRACT**

According to Public Health Agency of Canada, falls remain the leading cause of injury-related hospitalizations among seniors. Most fall interventions that have emerged in recent years have focused mainly on fall detection and prevention, however, these interventions come with limitations. This research involves the topic of falls management in the elderly, in particular, the role of health informatics technologies and methodologies in determining when an elderly individual is at risk of falling, how falls can be avoided and providing the personalized support once fall has taken place. The purpose of this research is to design a mobile application for the management of falls among the elderly using the constructs of an evidence-based conceptual model, the Patient Health Engagement (PHE) Model, and an evidence-based Clinical Frailty Scale (CFS). A mixed methods study evaluated the designed application and the study revealed that all participants favored the use of the application as an educational tool.



## **LIST OF ABBREVIATIONS USED**

PHE – Patient Health Engagement

CFS – Clinical Frailty Scale

PHAC – Public Health Agency of Canada

RM – Remote Monitoring

RMHC – Remote Model of Home Care

ICT – Information and Communication Technology

CTA – Center for Technology and Aging

EHR – Electronic Health Record

mHealth – Mobile Health

PERS – Personal Emergency Response System

QEII – Queen Elizabeth II Health Sciences Centre

NSHA – Nova Scotia Health Authority

UI – User Interface

App - Application

API – Application Programming Interface

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## CHAPTER 1: INTRODUCTION

Falls are common among the elderly and about a third of older people who live at home fall at least once a year [Laurence, 2016] and in half of such cases, the falls are recurrent [Tinetti & Kumar, 2010]. In the United States, falls are the leading cause of accidental death and the 7th leading cause of death in people who are 65 years and older [Laurence, 2016]. According to the Public Health Agency of Canada, falls remain the leading cause of injury-related hospitalizations among seniors and between 20% and 30% of seniors fall each year. Because the risk of injury due to falls increases with age, falls among this population tend to lead to severe consequences. Falls among the elderly have several causes, and fall risk factors can be intrinsic and extrinsic. Intrinsic factors include a history of falls, advanced age, impaired mobility and gait, medical diseases, medication, sedentary behavior, fear of falling, visual impairments, foot problems, nutritional deficiencies and impaired cognition [Tacconi et al, 2011]. Extrinsic factors include environmental hazards (e.g. poor lighting, slippery floors and uneven surfaces), footwear and clothing and inappropriate walking aids or assistive devices [Tacconi et al, 2011]. Meta-regression analysis of the predisposing risk factors has shown that gait difficulties, muscular weakness and an impaired standing balance are the most prevalent risk factors for falls [American Geriatrics Society et al, 2001]. Over half of all falls result in slight injuries, such as a bruise, a sprained ligament, or a strained muscle [Laurence, 2016]. Some serious injuries could include torn ligaments, deep cuts, and damage to organs such as the kidney or liver. About 2% of falls result in a broken hip and other bones e.g. upper arm, wrist, and pelvis) are broken in about 5% of falls [Laurence, 2016]. Some falls could result in loss of consciousness or head injury while other falls may lead to more problems if individuals cannot get off the floor right away or call for help. Remaining on the floor,

even if it is for a few hours, can cause further complications such as pneumonia, low body temperature (hypothermia), dehydration, rhabdomyolysis (breakdown of the muscles which could lead to kidney failure or damage) and pressure sores (injuries to skin and underlying tissue caused by staying in one position for too long) [Laurence, 2016].

### **1.1. Falls Prevention and Management**

Falls and associated outcomes not only harm the injured individuals but also affect family, friends, care providers and the health care system [PHAC, 2014]. Although it is extremely helpful and important to detect and prevent falls, it is also important to prepare patients and caregivers with the understanding of what to do when there is an incidence of a fall. There is a lot of information on falls detection and falls prevention but limited data is available regarding what could be done immediately after a fall occurs among the elderly and before accessing the healthcare system. Also, the information available is distributed over various sources and is poorly organized. There is, therefore, a need to provide a platform for patients and their caregivers, where useful fall-related information is readily available for them to access quickly. The use of mobile health care has become progressively prevalent in self-care of various health conditions [Kang et al, 2016]. Mobile phones are essential in people's lives today and may serve as a platform for a variety of self-management tools such as apps [Holmen et al, 2014].

### **1.2. Collaboration with the Caring Near and Far Study**

This research was conducted in collaboration with a 4-year study, the 'Caring Near and Far study' (2016-2020), - funded by the Canadian Institutes of Health Research. This

pragmatic randomized controlled study aims to compare the use of Remote Monitoring (RM) technologies in the home with usual care as a means of supporting older adults to safely remain in their homes and avoid or delay advanced levels of care. However, there are gaps within homecare for complex care older adults which include [Donell & Regan, 2015]:

- Stretched health human resources
- Partial home care services and unmet home care needs
- Reliance on unpaid informal caregivers to sustain home care services with limited support to conduct this ‘care work’
- A chronic disease model of healthcare that assumes and expects client/caregiver ability for self-care
- Lack of direct support for or involvement of family caregivers in new models of home care
- Lack of innovative strategies to expand home care

The Caring Near and Far study proposes the development and evaluation of a technology enabled remote model of home care (RMHC). In the proposed study, RM components will be installed in the participant’s homes and home care service providers will provide real-time data access to enhance informal caregiver support, using the accumulated observations of daily living for historical analysis for trending, modeling & prediction and to improve real-time decision making regarding client care to determine safety (e.g. proper medication administration and falls).

### **1.3. Research Objectives**

The following objectives motivated our research:

- To design a mobile framework to provide personalized educational materials to the elderly and caregivers about falls management based on their levels of frailty, the type of fall they have i.e. whether they sustain any injuries or not and whether the fall was witnessed or not
- To design a mobile framework to improve and sustain patient and care-giver engagement in adopting good falls management practices
- To determine the usefulness and content suitability of the mobile framework to personalize falls management information to the elderly and their caregivers

**Overall, this research involves the topic of fall management in elderly, in particular, the role of health informatics technologies and methodologies in determining when an elderly individual is at risk of falling, how falls can be avoided and providing the personalized educational support once fall has taken place.**

### **1.4. Research Purpose**

The purpose of our research is to design a mobile application for the management of falls among the elderly using the constructs of both the Patient Health Engagement Model (PHE) [Graffigna et al, 2015] and a Clinical Frailty Scale (CFS) [Rockwood et al, 2005] and to evaluate its effects regarding perceived usefulness. The PHE Model is an evidence-based conceptual model that may be useful in understanding patient engagement and how it develops [Graffigna et. al, 2015] while the evidence-based

Clinical Frailty Scale (CFS) counts the numbers of deficits accumulated including diseases, physical and cognitive impairments, psychosocial risk factors and common geriatric syndromes [Jones, Song & Rockwood, 2004]. Therefore, we believe that using the constructs of these models will be essential in improving and sustaining patient and caregiver engagement while providing personalized information based on the patients' various levels of frailty. It is expected that this intervention will improve patient and caregiver knowledge on causes and risk factors of falls, help them follow fall prevention procedures and inform them on what to do given different situations that could occur after they or their loved ones experience a fall which in turn could reduce avoidable fall-related injuries and hospital visits.

### **1.5. Target Population**

The proposed research is geared towards educating the elderly/caregivers about best falls management practices by providing highly personalized information built on evidence-based theories. This will help us define our target population which includes the following:

- Males and females who are 65 years and older and live at home
- Individuals who may be frail and range between categories 1 and 7 on the frailty scale used for this research
- Individuals who may have an informal caregiver (could be family or friends)
- Individuals who can read and write English
- Individuals who have one or more chronic conditions
- Family or unpaid caregivers of elderly individuals

## **1.6. Contribution**

In this thesis, we create a falls management application prototype using a framework that incorporates both the Patient Health Engagement (PHE) model and the Clinical Frailty Scale (CFS). Previous studies [Menichetti & Graffigna (2016)] have evaluated the use of the Patient Health Engagement model for designing care management interventions for chronic older adult conditions. In this study, we combine the constructs of both the CFS and PHE model and evaluate the usability and suitability of the proposed framework for managing falls among the elderly.



## **CHAPTER 2: BACKGROUND**

### **2.1. Healthcare Management Among the Elderly**

There is an increase in the proportion of older adults across the world and this is primarily due to an increase in life expectancy [United Nations, 2002] and this rise in life expectancy increases the incidence of chronic diseases and the number of healthy elderly people [Kim et al, 2014]. The increase in life expectancy also leads to an increase in demand for healthcare management methods that do not involve hospital visits [Kim et al, 2014]. And because chronic diseases stretch over a period, patients need to possess the right tools and knowledge to perform self-care at home combined with periodic visits to the hospital [Inzucchi et al, 2012]. The use of information and communication technologies (ICT) for direct interaction with people or indirectly for other tasks has shown to contribute to the well-being and quality of life of the elderly [Ihm & Hsieh, 2015] and the use of ICT provides many services that support autonomy in old age by facilitating the execution of many routine tasks through e-services such as banking, shopping, and communication with social and health services [Keranen et al, 2017]. As reported by Wagner et al (2010), older adults are in many cases the fastest growing computer and internet user group worldwide.

### **2.2. Use of Mobile Health Technology Among the Elderly**

The rapid growth of mobile ICT within health service delivery and public health systems has provided new opportunities to deliver health services to patients, clinicians and caregivers alike [Mechael et al, 2010]. And the need for a healthcare system that helps elderly patients with various chronic diseases to consistently care for themselves at home

has prompted consideration of the use of mobile phones within the healthcare system [Kim et al, 2014]. According to Fox and Duggan (2010), 57% of American adults in 2010 had a wireless connection and used a laptop or mobile phone to access the internet and of these adults, 78% looked online for health information compared with 70% of internet users with desktop access and 59% of all American adults. It is important to note that of all mobile technology options, cell phones are the device of choice among adults over 50 [Center for Technology and Aging (CTA), 2011]. There are several areas where mobile health technologies have been implemented for use among the elderly [CTA, 2011] some of which are discussed further in the next section.

### **2.2.1. Chronic Disease Management**

Available mobile technologies provide a range of messaging, monitoring, and interactive communications functions to support interactive care processes, reduce unnecessary resource utilization, and improve care outcomes [CTA, 2011]. An example of mobile health technology for chronic disease management is a wireless mobile handheld device such as HealthPAL (<http://www.mtelehealth.com/medapps/healthpal.php>) which can collect data from peripheral monitoring devices in the home. The data collected are then communicated to an Electronic Health Record (EHR) where care providers can review the patient data. Another example is the In-home health monitoring system such as the Ideal Life Hub (<http://www.ideallife.com/>) which comprises of communication hub that connects with Ideal Life peripheral monitoring devices for health management applications in congestive heart failure, hypertension, asthma, and chronic obstructive pulmonary disease.

### **2.2.2. Medication Adherence**

Mobile health technologies for medication adherence can assist patients and caregivers [CTA, 2011] with obtaining proper medication information and patient education [Kleinman et al, 2017], medication organization [Abu-Dalbouh et al, 2015], dispensing [Kwan, 2013], dose reminders [Tan et al, 2013], and notification when doses are missed [Kwan, 2013]. An example is the pill phone app (<https://www.iwsinc.com/products/pillphone/>) which allows older adults to look up information on medications, create medication reminders, and receive reminders on their phones. With this app, older adults can get general drug information such as cautions, drug interactions, side effects, and a picture of what the medication looks like. Reminders can also be created around what drugs to take and times to take drugs. The app allows its users (older adults) to reply to alerts saying they took the medication, skipped it, or may “snooze” the alert to receive it later. The user’s responses are sent to an online patient record that can be accessed by patients or caregivers to track medication adherence patterns.

### **2.2.3. Safety Monitoring**

mHealth technologies for safety monitoring are used to promote safety and prevent injuries among the elderly. Examples of such technologies are fall detection and prevention technologies. Falls are so harmful to the elderly and so costly to society that if falling were a disease, it would be deemed an epidemic [Lohr, 2009]. Technologies for detecting falls either actively or passively assess an individual’s state whether a fall has taken place and alerts their caregivers [CTA, 2011]. Technologies for fall detection include personal emergency response systems (PERS) and passive sensors [CTA, 2011].

The PERS can be worn as bracelets, necklaces or embedded within mobile devices. Passive fall detection technologies utilize sensors such as motion sensors, pressure sensors, accelerometers and gyroscopes for monitoring of location, position, immobility, speed of motion and distance covered [CTA, 2011]. Fall detection technologies also include location tracking technologies which allow the caregivers of the elderly to locate those who are likely to wander. Most of these technologies involve the older adult carrying the location tracking device or mobile enabled tracking device, like a cell phone.

<b>Fall Detection Systems</b>	<b>Active or Passive</b>	<b>Description</b>
<b>Alarm with fixed or portable receiver and transmitter</b>	Active	Personal Emergency Response systems require older adults to activate a call button, which can either be stationary in a room or portable worn by the user. Some devices activate third party audio communication with the patient to address the situation and can contact the appropriate parties for further assistance.
<b>Location and position sensors with algorithms</b>	Passive	Sensors, like accelerometers and gyroscopes, are connected to the user and detect user's location and position in relation to the ground. Preset algorithms determine if movement is out of the scope of activities of daily living and is considered a fall. Software alerts third party or caregiver to potential fall.
<b>Motion sensors and pressure sensors with algorithms</b>	Passive	Motion sensor units are placed around the user's house or apartment on the walls or on the ground. Sensors continuously track user's motion. Preset algorithms determine whether user has fallen by analyzing immobility where users remain still in one area for longer than the allotted time. Software alerts third party or caregiver to potential fall.

Table 2.1 Fall Detection and Prevention Systems (Center for Technology and Aging, 2011)

#### **2.2.4. Access to Health Information**

mHealth technologies have the potential to give the elderly access to health information, allow for health information to be shared and coordinated, help to improve self-management and facilitate communication between the elderly, caregiver and their care provider [CTA, 2011]. Sharing of information may take place through a health record, social network, or in the form of sending/collecting physiological and other health data. The elderly can connect, share knowledge and provide support to other older adults and their care providers through social networking and care coordination technologies. More general health information can also be accessed through the Internet (not patient-specific), through mobile health applications while patient-specific information can be accessed through Personal Health Records (PHRs) and Electronic Health Records (EHRs).

#### **2.2.5. Wellness**

Wellness technologies are used for facilitating general wellness and as reported by the center for technology and aging they can be categorized into several groups including

- fitness(<https://www.fitbit.com/home>),
- nutrition([http://www.shroomies.com/nutrition\\_menu/index.html](http://www.shroomies.com/nutrition_menu/index.html)) and
- quality of life(<https://itunes.apple.com/us/app/livestrong-myquit-coach-dare-to-quit-smoking/id383122255?mt=8>).

These wellness interventions are usually mobile applications and vary in complexity and degree of interaction. For this research, our app will provide access to fall management information and will also be considered a wellness app that focuses on the quality of life of its users as it relates to falls management. It is very important to design content-

specific apps for the elderly as it will promote health education of the elderly, boost healthy practices and improve information dissemination on the topic.

### **2.3. Falls Detection and Prevention Among the Elderly**

Most fall interventions that have emerged in recent years have focused mainly on fall detection and fall prevention [Hawley-Hague et al, 2014] and this is very beneficial to the elderly because fall detection interventions help to identify when a fall occurs and alert their caregivers to the situation. The prevention interventions give both the elderly and their caregivers tips and practices that will help in preventing falls from occurring. Evidence-based methods to prevent falls include regular exercise, vitamin D supplementation and having regular fall risk assessments [Campbell et al, 1997; Feder et al, 2000; Gillespie et al, 2003; Tinetti, 2003;]. However, with these methods in place, falls are still very likely to occur as individuals age. This leads to a fear of falling which can be amplified in the presence of the “long lie”, which is identified as involuntarily remaining on the ground for at least an hour following a fall [Lord et al, 2007]. In a cohort study by Fleming et al (2008), it was reported that the “long lie” was seen in 30% of fallers. And as mentioned in the previous chapter, remaining on the floor after a fall for long periods (long lie) can lead to further health complications such as pneumonia, low body temperature (hypothermia), dehydration, rhabdomyolysis and pressure sores [Laurence, 2016]. PERS which can address this issue may sometimes not be useful because as reported by the Fleming cohort study [Fleming et al, 2008] it was found that around 80% of older adults wearing a PERS did not use their alarm system to call for help after experiencing a fall.

There has been an expansive body of work conducted in fall detection using a variety of solutions [Chaudhuri et al, 2014]. Some of these devices can compute different aspects of a fall ranging from the velocity of the fall to the impact of the fall and even the posture of the individual who has fallen. The usefulness of these devices is only maximized if it is always with the elderly individuals who are considered at risk of falling because only then can they detect fall velocities, fall postures and fall impacts experienced by these individuals. However, these devices are reliant on the elderly individuals not only remembering to wear the device but also choosing to wear the device which can be especially difficult at nighttime [Litvak et al, 2008; Noury et al, 2007; Prado-Velasco et al, 2008; Zhang et al, 2011]. There are also non-wearable systems which do not rely on the individuals to remember to use them, but these systems are usually limited to a specific space [Sixsmith & Johnson, 2004]. A solution to both these issues is using multiple sensors (wearable and non-wearable) to account for the weaknesses in each device, however, adding more and more devices could overwhelm the elderly causing them to reject such systems [Chaudhuri et al, 2014]. Studies have shown that the elderly are favorable to fall detection technologies [Brownsell & Hawley, 2004; Horton, 2008; Londei et al, 2009; Marquis-Faulkes et al, 2005] and because they want to be able to live at home, they are willing to accept new technologies that support their independence [Brownsell et al, 2000; Brownsell & Hawley, 2004]. Falls are a serious issue for older adults and technologies can help prevent them but also help older adults deal with them [Hawley-Hague et al, 2014].

There are numerous advantages associated with the use of fall detection and prevention interventions however, these interventions come with some limitations. These limitations

include the lack of personalized educational materials for falls management and the lack of patient and caregiver engagement approaches to providing this information. Therefore, there is a need for an intervention that offers more functionalities than just detection and prevention of falls, such as those that might educate older adults and their caregivers about post fall procedures that could reduce health risks after a fall. And, educating them on practices they can incorporate into their everyday lives that will help reduce or prevent falls from occurring which will give the elderly a sense of autonomy and independence. Our research hopes to address these limitations by providing personalized educational falls management information to the elderly and/or their /caregivers based on levels of frailty and focus on improving and sustaining patient and caregiver engagement in adopting falls management practices.



## **CHAPTER 3: RESEARCH APPROACH TOWARDS PATIENT/CAREGIVER ENGAGEMENT AND PERSONALIZATION**

We are proposing the design of a mobile framework for the elderly/caregivers to promote their engagement around detection, prevention and management of falls. Patient and caregiver engagement entails involving the patient and their caregivers in every step or aspect of their healthcare management process. It is how providers or healthcare organizations solicit patients' needs and preferences to ensure they are delivering patient-centered care [Whyte & Sium, 2016]. And because falls among the elderly is not an occurrence that can be eliminated even when fall prevention measures are put in place, it is highly essential that patients and their caregivers are engaged by providing them with easily accessible information in the case of an incident. It is known that the use of new technology presents extraordinary strengths in engaging individuals [Graffigna et al, 2015]. These interventions help patients manage emotional and personal discomfort associated with the illness experience [Triberti & Liberati, 2014]. For example, Personal Health Records designed to include information about patients' values, health goals, and action plans proved to be particularly efficient in fostering positive behavioral changes in patients [Chunchu et al, 2012]. Another example is, virtual rehabilitation which is currently adopted for the treatment of several types of disabilities following strokes [Laver et al, 2015] and cognitive or psychological impairments [Riva et al, 2004]. In this way, technological interventions allow patients to gain the highest possible level of autonomy and quality of life [Graffigna et al, 2015].

### **3.1. Why Patient and Caregiver Engagement?**

Patient and caregiver engagement is considered in designing our intervention because as reported by Greene & Hibbard [2012], it is related to a better quality of care, which improves patient's clinical indicators and compliance to recommended regimens. It also contributes to promoting sustainable lifestyles and avoiding unsafe conducts [Jordan et al., 2008; Reid et al., 2010] by giving patients an idea of what the consequences of unhealthy behaviors are. The engagement of caregivers affords them the opportunity to become substitute care managers in the absence of multidisciplinary care thus bridging service information and coordination gaps to provide long-term care for patients [Bolmsjo et al, 2001]. Involving the caregivers will inform them on how to make their loved ones autonomous in the care process.

### **3.2. Theoretical Underpinning of the Proposed Mobile Framework**

ICT can be used in various ways in the care of the elderly particularly in the care of frail seniors [Keranen et al, 2017]. The proposed mobile application has been designed to be used by elderly individuals who may be frail, may have caregivers who assist in their care and they live with one or more chronic conditions. The proposed framework is based on evidence based frailty index and health theory. There are numerous definitions for frailty but for our research, we applied the definition by Rockwood et al, (2005) stating that frailty is a term widely used to denote a multidimensional syndrome of loss of reserves (energy, physical ability, cognition, health) that gives rise to vulnerability.

### **3.2.1. The Clinical Frailty Scale (CFS)**

We have applied an evidence-based clinical frailty scale to design the proposed mobile intervention [Rockwood et al, 2007; Rockwood et al, 2005]. This clinical frailty scale will help in personalizing the falls management information based on individual's levels of frailty. The falls management information will be personalized based on whether the user is frail enough to be dependent on a caregiver or not. If the user's level of frailty shows that they are dependent on a caregiver, they are provided with information to educate both patients and caregivers on falls management. And if the user's level of frailty shows that they require no assistance from caregivers, they are provided with information to educate patients on falls management. When compared with other frailty indexes such as the Fried frailty phenotype [Fried et al, 2001] which includes measurements not routinely used for patient assessment [Dent et al, 2016] and the Frailty Index of accumulative deficits [Rockwood & Mitniski, 2007] which can be time consuming to calculate because of its mathematical nature [Hubbard et al, 2009], the clinical frailty scale is very precise, easy to understand and easy to use. The different categories within the clinical frailty scale make it easy to evaluate what category an individual belongs to so that the best information is given. Also, in one study where the clinical frailty scale was compared with two other measures of frailty (Cardiovascular Health Survey Phenotypic Definition of Frailty, The Frailty Index) it was concluded that each of the three measures had strengths and all identified people at increased risk of adverse outcomes [Rockwood et al, 2007]. The researchers also concluded that the clinical frailty scale and the Cardiovascular Health Survey Phenotypic Definition of Frailty were suitable for use in situations where administration (or management) is the

goal. Therefore, we strongly believe that the clinical frailty scale is appropriate to be used in our falls management app. Finally, the domain expert on our advisory panel also suggested utilizing the clinical frailty scale to categorize elderly on the basis of their frailty [April Negus, NP personal communication].

The clinical frailty scale counts the numbers of deficits accumulated including diseases, physical and cognitive impairments, psychosocial risk factors and common geriatric syndromes [Jones, Song & Rockwood, 2004]. The implemented clinical frailty scale ranges from categories 1 to 9.

- Category 1 is very fit: Individuals who are robust, active, energetic and motivated. They are among the fittest for their age.
- Category 2 is well: Individuals who have no active disease symptoms but are less fit than category 1. They often exercise or are very active occasionally.
- Category 3 is managing well: Individuals whose medical problems are well-controlled but are not regularly active beyond routine walking.
- Category 4 is Vulnerable: Individuals are not dependent on others for daily help, however, their symptoms limit their activities.
- Category 5 is mildly frail: Individuals usually have more evident slowing and need help in high order instrumental activities of daily living (finances, transportation, heavy housework, medications).
- Category 6 is moderately frail: Individuals need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance with dressing.

- Category 7 is severely frail: Individuals are completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at risk of dying (within ~ 6 months).
- Category 8 is very severely frail: Individuals are completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.
- Category 9 is terminally ill: Individuals approaching the end of life. They have a life expectancy of fewer than 6 months but are otherwise not evidently frail.

The proposed application only caters to individuals within category 1 to 7 on the frailty scale because categories 8 and 9 are individuals who could not recover even from minor illness and are approaching the end of life (with a life expectancy of < 6 months). And according to a study by Fowler & Hammer (2013), elderly Canadians say that they will prefer a treatment plan that focuses on providing comfort rather than a technology-supported death. Also, individuals in this category may be in a hospice where they will not require a falls management app since they are in the care of medical professionals.

### **3.2.2. Patient Health Engagement (PHE) Model**

As discussed in section 3.1, there are several advantages to engaging patients and their caregivers in the patient's healthcare process and this has influenced the selection of the model used for this research. We have used Patient Health Engagement (PHE) Model [Graffigna et. al, 2015]. to inform the design of the proposed mobile application to maximize elderly and care-giver engagement. PHE is an evidence-based conceptual model that may be useful in understanding patient engagement and how it develops [Graffigna et. al, 2015]. The PHE model has been developed based on a combination of

the perspective of consumer psychology and more than 10 years of research and practice dedicated to the in-depth understanding of patients' perspectives about their illness journeys [Graffigna et al, 2015]. Patient Health Engagement is a multi-dimensional psychosocial process resulting from the conjoint cognitive, emotional and behavioral enactment of individuals toward their health conditions and their health management [Graffigna et al, 2014]. The main concept in the PHE model is patient engagement and gaining insights on how patient engagement progresses along the different phases is very important in designing interventions that patients and individuals in their circle of care will utilize. According to the model, after the diagnosis of a chronic illness, a patient goes through a sequence of four stages which demonstrate different requirements for engagement in care. The four stages of patient engagement featured by the PHE model are the blackout, arousal, adhesion and eudaimonic project stages [Graffigna et. al, 2014]. In the blackout phase, patients feel like they are in a state of suspense and they cannot fully understand all the information they receive about their respective conditions. They feel the critical event is out of their control. They need to obtain support to cope with their new healthcare situation. By promoting patients' understanding of their respective conditions, they move to the arousal stage of patient engagement.

At the arousal phase, patients are hyper-attentive to every signal in their bodies. In comparison to the blackout phase, patients are better informed about their health condition even though their health knowledge is still simplistic. Patients acquire some knowledge about their conditions and with a better understanding they become more alert. Patients begin to learn and test self-management patterns and cope with their health

statuses more effectively. This gives them the confidence to manage their own health and moves them to the next phase of patient engagement (adhesion).

At the adhesion phase, patients acquire a broader spectrum of health literacy and behavioral skills. Patients come to accept their conditions and adhere to rules given by their care providers. And the need to make and maintain healthy living moves patients to the last stage of patient engagement (eudaimonic project).

At eudaimonic project phase, patient absorbs self-management behaviors and practices into their daily lives and can even assist other individuals living with the same conditions as they are or who share similar experiences as themselves. They are no longer overwhelmed but rather become more satisfied with their quality of life and are capable of enacting more effective health management.

The PHE model also features the caregiver engagement aspect, which is connected to the phases of patient engagement. For each patient engagement phase, there is a corresponding caregiver engagement phase to assist the patient to move through all the phases of engagement and finally, arrive at the point where they can manage some (if not all) aspects of their health. At the first caregiver engagement phase called the consoler phase, the caregiver provides information on the condition, emotional normalization, and support to the patient who at this point is at the blackout stage of patient engagement. The next phase is called the nurse phase where the caregiver provides information about practical management of the situation and changes to daily life. The third phase is the safety guard phase. At this phase, the patient is equipped with tools to gain some level of independence, however, the caregiver is still a key figure in the case of emergencies. The last phase called the Life Buddy is the phase where both the caregiver and patient have all

the awareness of the situation and the caregiver attends the patient as a partner who shares their life experience with them.

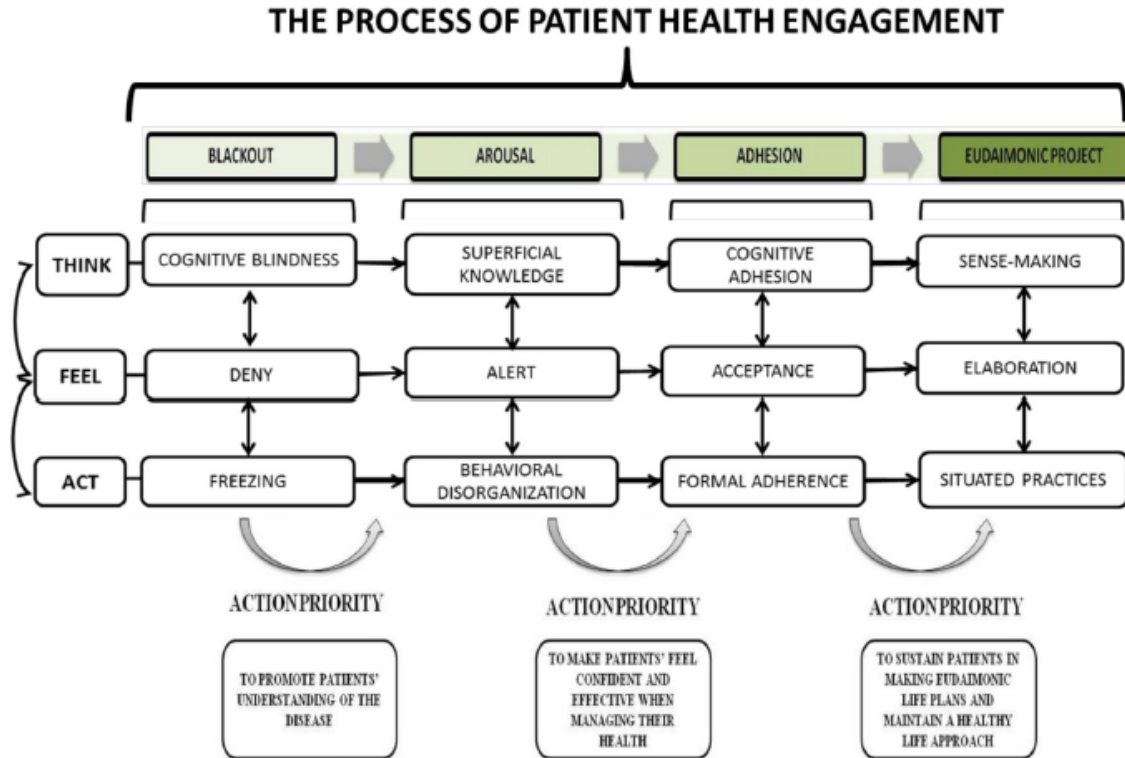


Figure3.1 The Patient Health Engagement Process (Adapted from Graffigna et al, 2014)

In a study by Menichetti & Graffigna (2016), the PHE model was implemented to design a theoretically-driven program which was aimed at improving the engagement of older chronic patients in their care management. The study concluded that while patients reporting high levels of engagement at baseline maintained their baseline scores after training, patients with lower levels of engagement at baseline improved their scores after the training.

Although there have been no studies where the PHE model was implemented in the design of a mobile app, we strongly believe that since using the model has previously



helped in improving engagement in older chronic patients, incorporating the PHE concepts in the model for designing our intervention is the best fit for our design. This is because maximizing the full capabilities of our app depends on its continued use so that users can get to the point where they incorporate the falls management information into their daily lives, therefore, improving and sustaining patient and caregiver engagement is important.

Considering the PHE model, health technologies built by analyzing the user experience may sustain engagement by truly understanding the individuals' care expectations [Graffigna et al, 2015]. We involved domain experts (nurses who work in the QEII Health Sciences Centre, Geriatric Day Hospital/falls clinic) in the entire design phase of our intervention. It was noted that most of the elderly when they fall, and they are alone, do not know how to safely get off the floor or even call for help. And when they find themselves in circumstances like that, they feel helpless and terrified which makes them shy away from their usual activities of daily living, therefore, losing their independence and self-confidence.

Also by understanding the various phases of both patient and caregiver engagement, we have designed our intervention to bring knowledge to caregivers in a format that is easy to understand and easy to incorporate into their everyday lives and that of their loved ones while sustaining their engagement. Therefore, giving them and their loved ones the confidence to make certain decisions without fear when a fall occurs and thus preventing further injuries that could occur.

### 3.2.3. Combining the CFS and PHE model

The design of our intervention was informed by utilizing the constructs of the Patient Health Engagement (PHE) model [Graffigna et al, 2015] and a Clinical Frailty Scale (CFS) [Rockwood et al, 2005]. We have termed our combined model a hybrid model and this is because it integrates the components from the clinical frailty scale and the PHE model. The hybrid model comprises four patient engagement phases (as in the PHE model) and within each of the patient engagement phase, there are 7 categories of frailty (categories 1 to 7). These categories within each of the patient engagement phases make it possible to provide further personalized information for each category of persons within each phase.

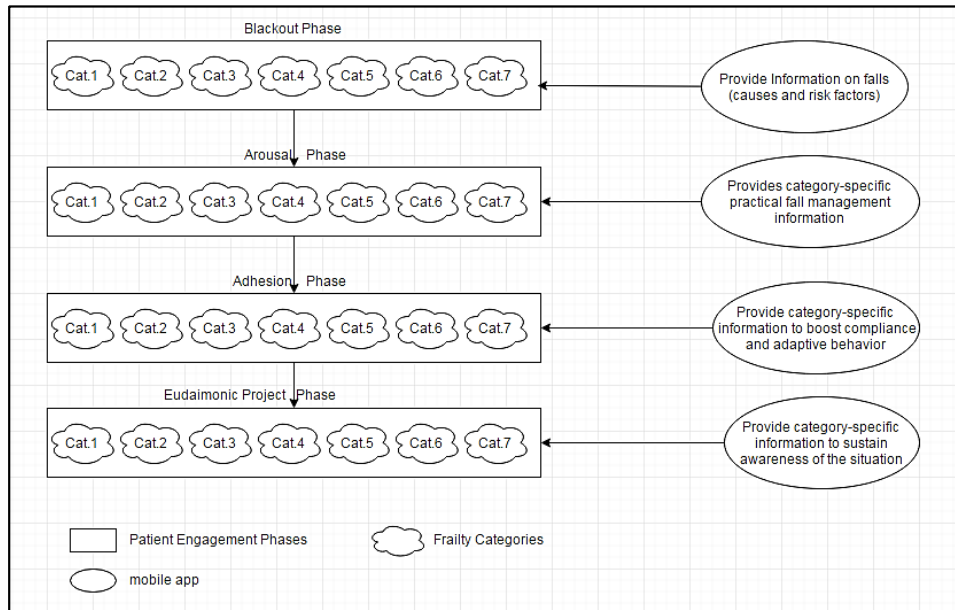


Fig.3.2 Stages of the Patient Health Engagement Process in the Hybrid Model

## **CHAPTER 4: METHODS**

The falls management application was designed to educate the elderly and their caregivers on post fall procedures, fall prevention tips, fall risk factors and fall causes. This application will improve their knowledge on what to do when a fall occurs, help boost their independence and reduce their fear of falling and health risks associated with falling. This chapter outlines the processes involved in the development of the falls management application prototype, and it includes the conceptual phase, operationalizing the working model, content development and the design phase.

### **4.1. Conceptual Phase**

A literature review was performed to determine what could be done after a fall incident occurs among the elderly, how to help the elderly avoid falls and identify when they are at risk of falling. The review identified various procedures that could be followed immediately after a fall occurs among the elderly, risk factors, causes and prevention tips for falls. The review further identified that the correct post fall procedure to follow will depend on the state of the individual after the fall occurs and whether the fall was witnessed by their caregivers or not [PHAC, 2015; Safe Life Senior, 2015]. Based on the different steps that could be taken with respect to the state of the individual after the fall, and if the fall was witnessed or not, we developed a falls management flow diagram (see Appendix A & B), which was clinically validated by our domain experts. The flow diagram was used as a blueprint in designing the fall management app prototype by implementing the hybrid model discussed in section 3.2.3.

### 4.1.1. Conceptual Process Flow

A user's navigation of the application is outlined below. The process flow steps are as follows:

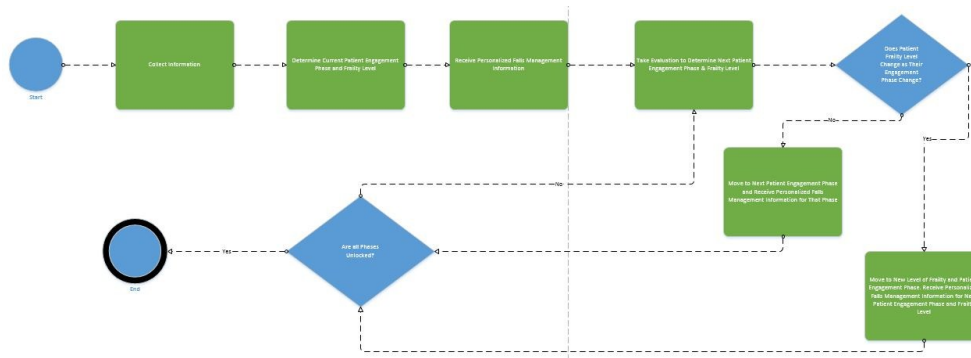


Figure 4.1 Conceptual Process Flow

- Collect Information: a user enters their username and password.
- Determine current patient engagement phase and Frailty Level: a set of evaluation questions are completed by the user to help determine their patient engagement phase. After which they will be directed to the clinical frailty scale to select a level on the frailty scale they think they/their loved one belongs.
- Receive personalized fall management information: based on the determined patient engagement phase and frailty level, fall management information is presented to the user.
- Take evaluation to determine next patient engagement and frailty level: After the user gets the personalized falls management information, they take the evaluation

questions again to determine if their level of frailty and patient engagement phase both change or if only the patient engagement phase changes.

- Move to next patient engagement phase and receive personalized falls management information for that phase: If only the patient engagement phase changes and the level of frailty remains the same, the user receives personalized falls management information for the new phase.
- Move to new level of frailty and patient engagement phase: If both the patient engagement phase and the level of frailty changes, the user receives personalized falls management information for the new patient engagement phase and frailty level.
- The process ends when all four phases of information have been unlocked.

#### **4.2. Operationalizing the Working Model**

Based on the rationale described in section 3.2.3., to operationalize the hybrid model, we have designed a decision table to get all possible combinations of the PHE model and clinical frailty scale concepts. There were 28 possible combinations of the PHE model & frailty scale concepts (4 stages of the PHE model and 7 categories of the frailty scale) and 6 possible recommendations.

CONDITIONS																		
Frailty Category	Cat.1	Cat. 1	Cat.1	Cat.1	Cat.2	Cat.2	Cat.2	Cat.2	Cat.2	Cat.3	Cat.3	Cat.3	Cat.3	Cat.4	Cat.4	Cat.4	Cat.4	
PHE Phase	Phase1	Phase2	Phase3	Phase4	Phase1	Phase2	Phase3	Phase4	Phase1	Phase2	Phase3	Phase4	Phase1	Phase2	Phase3	Phase4	Phase1	
<b>RECOMMENDATIONS</b>																		
Action1	X				X					X				X				X
Action2		X				X					X					X		
Action3																		
Action4			X			X					X					X		
Action5				X	X			X	X				X	X			X	X
Action6		X	X				X	X				X	X			X	X	
<b>RECOMMENDATIONS</b>																		
Action1: Get information on possible causes and risk factors for falls																		
Action2: View images teaching what to do in the incidence of a fall																		
Action3: Follow postfall procedure for caregivers who witness a fall																		
Action4: Follow fall prevention guide																		
Action5: Follow postfall procedure for when you are alone and/or can't get up																		
Action6: Get information on things to have the doctor check after a fall																		

Fig 4.2 Decision table showing patient engagement phases and respective categories of frailty

When a user logs in to use the application, there will be information (in the about the app section) letting the user know that there are four phases of information the application will provide and that there will be a set of questions to evaluate what phase the user falls into the first time they use the app and at the end of every phase. And it is expected that after getting the information from their current phase, they can progress to the next phase. To make the app easy to use and not tedious, we will have 5 questions. The first 4 questions will help determine what patient engagement phase the user belongs and the last question will help determine their frailty category. The first 4 questions have been designed based on the questions designed by Graffigna & Bonanomi [2015], in measuring patient engagement. While the last question is adapted directly from the Rockwood Clinical Frailty Scale. The first 4 questions will be as follows:





1. When I think about a fall occurring I feel:
  - Overwhelmed
  - Like I want to know what to do
  - Like I am aware

- Like I fully understand what to do
2. When I think about managing a fall incident I feel:
- Overwhelmed
  - Curious to know how to manage a fall
  - Like I am aware
  - Like I fully understand what to do
3. When I think about fall prevention procedures I feel:
- Like I have no idea
  - Curious to know
  - Like I have some knowledge
  - Like I fully understand fall prevention procedures
4. When I think about what to ask my physician after a fall I:
- Have no idea
  - Want to know what to ask
  - Have some knowledge of what to ask
  - Feel like I fully understand what to ask my physician




Each of the options of the questions are weighted and they are weighted differently. The first options for each question are weighted 1, the second options for each question are weighted 2, the third options for each question are weighted 3 and the fourth options are

weighted 4. After answering all four questions, a user can have a score ranging from 4 to 16. If a user gets a score ranging from 4 to 7, they belong to blackout phase. If a user gets a score ranging from 8 to 11, they belong to the arousal stage. If a user gets a score ranging from 12 to 15, they belong to the adhesion phase. And when a user gets a score of 16 they are in the eudaimonic project phase. After the user, has been scored and their patient engagement phase is determined, they are asked the last question which is as follows:

5. Which of the following categories best describes you?

-  You are robust, active, energetic, motivated and you exercise regularly.
-  You do not exercise regularly but you do so often or you are very active occasionally.
-  You are not regularly active but you walk routinely.
-  You complain of being “slowed up”, and/or being tired during the day.



-  You complain more of being “slowed up” and you need help with activities of daily living such as finances, transportation, medication, heavy housework, and walking outside.
-  You need help with all outside activities and inside you need help with stairs and might need assistance with bathing & dressing.
-  You are completely dependent on a caregiver for personal care.

The option the user picks for this question automatically determines what category on the frailty scale they belong, ranging from category 1 to 7 with category 1 being the first option and category 7 being the last option. If we assume that a user scores a total of 6 from the first four questions and picks category 5, it means that the individual is a mildly frail person who is in the blackout phase. The app will provide the relevant (user-specific) information based on the patient engagement phase and frailty category they belong to and pop-up notifications will be used to tip the user to wait for a week for the information to settle in before moving to the next phase. After this, the user is evaluated again using the same questions as at the beginning to determine if the user is still in the same phase or if they are ready to move to the next phase. It is expected that the user gets a higher score which will enable them to move to the next phase and get more falls management information and progress on and on till they get to the last phase

(eudaimonic project phase). It is important to note however that in interventions which have stages or phases, clients move in and out of recovery stages in a nonlinear process and a client may fall back, but not necessarily back to the beginning [Gilbert et al, 2005].

If a user gets a score that keeps them on the same stage or takes them back to a previous stage, then another measure is suggested to help move the user to the next stage. The measure in our app is a decisional balance measure. Other measures such as motivational interview and social support were considered as well. However, decisional balance promotes self-management and self-efficacy more than the other two measures. The motivational interview should involve a health professional and for social support, it might take some time for users to find a social network that will feel comfortable for users to belong to.

At this point, the app will use the decisional balance measure and provide a list of things to consider and ask the user to arrange them as pros or cons. The decisional balance technique (Miller & Rollnick, 2002) helps people think through their ambivalence in an open and systematic way. It helps the patient to deepen their self-understanding and reflect on their own behavior and because of the exercise the patient's perceived importance for changing (or confidence about changing) is likely to increase and alongside this their motivation and readiness to change may also increase [Passmore, 2011]. The decisional balance measure used in this research was clinically validated by our domain experts

Decisional balance is a measure used to help patients consider the pros and cons of their current behavior and the pros and cons of changing. The list of things to consider will be as follows:

- Getting more knowledge about falls
- Getting knowledge on managing a fall incident
- Getting education on fall prevention procedures
- Getting knowledge on what to ask the physician after I or my loved one fall
- Getting knowledge on what to do if I witness a fall
- Being more confident because of the knowledge I have acquired so far

If the pros equal the cons or the pros are greater than the cons, then the user moves to the next phase. But if the pros are less than the cons the user remains in their current stage until they are ready to move to the next phase.

If a user takes the evaluation test and their levels of frailty change alongside the phase of patient engagement they belong to then they are presented with information related to their new levels of frailty and patient engagement. If they move in and out of stages in a nonlinear process as suggested by Gilbert et al, [2005], they are also presented with information related to the levels of frailty and patient engagement they belong right after they take the evaluation.

### **4.3. Content Development**

Content development involves researching, writing, gathering, organizing, and editing information for publication on a website or a mobile application. In the content development phase, the data that was collected during the review of the literature, which is shown in the following sections was consolidated and used as content for the falls management application. And this content was validated by our domain experts.

#### **4.3.1 Fall Prevention Tips [NSHA, 2016]**

- Use assistive devices and safety equipment as directed by your occupational therapist or physiotherapist
- Have your eyesight and hearing tested regularly
- Review all your medications with your healthcare provider and/or pharmacist on a regular basis
- Exercise regularly with the advice of your health care provider, to improve your muscle strength, balance and coordination
- Eat a well-balanced diet
- Limit the amount of alcohol you drink
- Get up slowly after lying or sitting down. Make sure you are not dizzy before standing up
- Don't carry large or awkward things that can throw you off balance
- Have your telephone or cellphone in easy reach. A cordless phone at your bedside is a good idea
- Keep emergency numbers in large print next to each phone
- Think about wearing an emergency response button

#### **4.3.2. Risk Factors for Falls [Studenski & Wolter, 1998]**

- Demographic factors: Older age (especially  $\geq 75$  years), Housebound status, Living alone
- Historical factors: Use of cane or walker, previous falls, acute illness (such as flu, breaking a bone, asthma attack, heart burn, burns, etc.), conditions that affect the muscles (causing symptoms such as muscle weakness, loss of muscular control, twitching, spasming, muscle pain), medications (especially the use of four or more prescription drugs).
- Physical deficits: Having trouble remembering, learning new things, concentrating or making decisions that affect everyday life. Reduced vision, difficulty rising from a chair, foot problems, neurologic changes (unbalanced body posture causing individual to develop forward or backward lean, slowed time to perform simple reflexive functions (response to stimuli). Diminished ability to respond to or be aware of light touch, vibration and temperature. Decreased hearing.
- Others: Environmental hazards and Risky behaviors.

#### **4.3.3. Common Causes of Falls [Yoshikawa et al, 1993]**

- Accident
- Environmental hazard
- Fall from bed
- A deviation from normal walking pattern

- Disturbances that cause individuals to feel unsteady, giddy, woozy or have a sensation of movement, spinning or floating
- Weakness and pain related to arthritis
- Vertigo (sensation of feeling off balance)
- Medications or alcohol
- Acute illness such as flu, breaking a bone, asthma attack, heart burn, burns, etc.
- Confusion & having trouble remembering, learning new things, concentrating or making decisions that affect everyday life
- Drop in blood pressure that happens when an individual stands up from sitting or lying down leading to lightheadedness, dizziness or fainting.
- Visual disorder
- Disorders that affect the structure or function of either the spinal cord or the brain
- Fainting (sudden loss of consciousness usually temporary and typically caused by lack of oxygen to the brain)
- Sudden spontaneous falls while standing or walking with complete recovery within seconds or minutes
- Epilepsy.

#### 4.3.4. Drugs That May Increase Risk of Falling [Fuller, 2000]

- Sedative-hypnotic and anxiolytic drugs such as secobarbital (Seconal), pentobarbital (Nembutal), diazepam (Valium), chlordiazepoxide (Librium), chlorazepate (Tranxene), methaqualone (Quaalude), ethchlorvynol (Placidyl), chloral hydrate (Noctec), mebroamate (Miltown), Ativan (Lorazepam), celexa (Citalopram), buspar (Buspirone), cymbaltar (Duloxetine), Adderall.
- Tricyclic antidepressants such as Amitriptyline, Amoxapine, desipramine (Norpramin), Doxepin, imipramine (Tofranil), nortriptyline (Pamelor), protriptyline (Vivactil), trimipramine (Surmontil).
- Major tranquilizers such as chlorpromazine (Thorazine), fluphenazine (Prolixin), prochlorperazine (Compazine), trifluoperazine (Stelazine), mesoridazine (Serentil), thioridazine (Mellaril), haloperidol (Haldol), clozapine (Clozaril), loxapine (Loxitane), risperidone (Risperdal), olanzapine (Zyprexa), quetiapine (Seroquel), ziprasidone (Geodon).
- Antihypertensive drugs such as hydrochlorothiazide (Microzide), chlorthalidone, acebutolol (Sectral), atenolol (Tenormin), lisinopril (Zestril), benazepril (Lotensin), captopril (Capoten), candesartan (Atacand), losartan (Cozaar), amlodipine (Norvasc), diltiazem (Cardizem, Tiazac, etc.), Aliskiren (Tekturna), doxazosin (Cardura), prazosin (Minipress), carvedilol (Coreg), labetalol (Trandate), clonidine (Catapres and Kapvay), guanfacine (Intuniv and Tenex), methyl dopa, hydralazine, minoxidil, spironolactone (Aldactone), eplerenone (Inspra).

- Cardiac medications such as rivaroxaban (Xarelto), dabigatran (Pradaxa), apixaban (Eliquis), heparin, warfarin (Coumadin), clopidogrel (Plavix), dipyridamole, prasugrel (Effient), ticagrelor (Brillanta), benazepril (Lotensin), captopril (Capoten), enalapril (Vasotec), fosinopril (Monopril), lisinopril (Prinivil, Zestril), moexipril (Univasc), perindopril (Aceon), quinapril (Accupril), ramipril (Altace), trandolapril (Mavik), Sacubitril/valsartan (Entresto).
- Corticosteroids such as hydrocortisone (Cortef), cortisone, ethamethasoneb (Celestone), prednisone (Prednisone Intensol), prednisolone (Orapred, Prelone), Fludrocortisone (Florinef).
- Nonsteroidal anti-inflammatory drugs such as aspirin, salsalate (Amigesic), celecoxib (Celebrex), diclofenac (Voltaren), etodolac (Lodine), ibuprofen (Motrin), indomethacin (Indocin), ketoprofen (Orudis), ketorolac (Toradol), nabumetone (Relafen), naproxen (Aleve, Naprosyn), oxaprozin (Daypro), piroxicam (Feldene), sulindac (Clinoril), tolmetin (Tolectin).
- Anticholinergic drugs such as Parkinson's medications, diphenhydramine (Benadryl), trihexyphenidyl (Artane), benzotropine mesylate (Cogentin), biperiden (Akineton), antipsychotics, clomipramine (Anafranil), chlorpromazine (Thorazine), clozapine (Clozaril), fluphenazine (Prolixin), loxapine (Loxitane), olanzapine (Zyprexa), perphenazine (Trilafon), pimozide (Orap), quetiapine (Seroquel), thioridazine (Mellaril), thiothixene (Navane), trifluoperazine (Stelazine).



- Hypoglycemic agents such as metformin, glyburide, glipizide, glimepiride, tolazamide, tolbutamide, Pioglitazone, rosiglitazone.
- Any medication that is likely to affect balance

\*\*\*\*\*This list of drugs is not exhaustive

#### **4.3.5. Fall Prevention Guide (NSHA, 2016)**

- **Stairs:** Install handrails on both sides of your stairs. Make sure the handrail is as long, as the stairs. Always keep stairs free of clutter. Make sure stairs have a light switch at both the top and the bottom. Ask someone to fix loose or uneven steps and handrails. Make sure that carpet is firmly attached to the stairs or attach non-slip rubber treads on stairs if there is no carpet. Ask someone to paint your outside steps with a mixture of sand and paint for better grip. Ask someone to keep your walkways and outside steps clear of snow, ice, newspapers and leaves. Always have a light on for your outdoor entrances and stairs.
- **Kitchen:** Keep things you use often in easy reach, either on the lower shelves or on the counter. Do not climb to reach things. Plan your meals ahead of time. Think about using a meal delivery program or buy meals that are easy to make. If you use a walker, a tray attachment makes it easier and safer to carry things around your kitchen.
- **Bathroom:** Consider safety equipment for the bathroom such as grab bars, raised toilet seats, bath benches or seats. Have a non-slip rubber mat or non-slip adhesive strips put in your tub. If you have a hard time getting in and out of your tub, try sponge-bathing, modify your tub, consider a walk-in shower.

- Clothing: Wear non-slip, low-heeled shoes, or slippers that fit well. Do not walk around in socks because they can be more slippery than shoes or slippers with a good sole. Wear clothes that will not get in the way of walking or moving. Dresses or pants that are too long can get in the way.
- In your home: Make sure all areas of your home are well lit. Have a lamp or light switch near your bed that you can reach without getting up. A “touch lamp” is a good idea. Have a night light in your hallways, bedroom and bathroom. Keep pathways to all the rooms free of clutter. This is very important if you use a walking aid. Take out small mats and rugs that are not fixed to the floor. Keep electrical wires and telephone cords safely out of pathways.

#### **4.3.6. Things to Have the Doctor Check After a Fall (Kernisan, 2014)**

- An assessment for underlying new illness
- A blood pressure and pulse reading when sitting and when standing
- Blood tests
- Medications review
- Gait and balance assessment
- Vitamin D levels assessment
- Evaluation for underlying heart conditions or neurological conditions
- Vision, podiatry and home safety referrals

In the falls management application, some phases such as Phases 2 and 3 contain images showing what an individual should do if they witness a fall (Appendix F), what an individual should do when they fall, (Appendix C and D) and what an individual should do when they can't get up after a fall (Appendix E). The final phase of patient engagement in the falls management application contains the process flow of the various post fall procedures as seen in the post fall flow diagram (Appendix A and B) presented in an interactive format (Appendix J)

#### **4.4. Development of App Prototype**

In the development phase of this research, the main artifact produced was the app prototype. We discuss the market analysis that was performed to choose the best prototyping tool for our research. In further sections, we have discussed the architectural design of the actual application prototype. We also discuss scenarios which show how the app will give tailored information to users based on their level of frailty and patient engagement phase.

##### **4.4.1. Prototyping**

In the prototyping phase of our design, a market analysis of available prototyping tools was performed and based on what tools have a free version and could be used for prototyping 3 types of apps (ios, androids and web) several prototyping tools were selected. The selected tools were Codiqa Web, Evolus Pencil, Fluid UI, Invision, Marvel, Justinmind and Weld. It is important to note that this list is not exhaustive but for our research we considered only the above listed tools. After this step, tools which support both gestures and transition effects were then selected which left us with the following

four tools: InVision, Marvel, Justinmind and Fluid UI and made comparisons. Based on our needs and preferences we compared these four tools. Our comparison was made based on several requirements which are discussed below.

#### **4.4.1.1. Requirements Consideration**

- **Learning the Tool**

It is normal to experience a bit of a learning curve when using a tool for the first time. However, none of the tools require any coding and they all have tutorials available on the web teaching how to use them.

- **Registration Process**

The registration process for all the tools seemed easy enough except for Justinmind which must be downloaded to users' devices. They only included entering a name, email and password to register which should only take 15 to 20 seconds.

- **Cost of the Tool**

1. InVision: This tool has 5 versions. The free version which gives access to design one prototype, the starter version which costs \$15 per month and gives access to design 3 prototypes, the professional version which costs \$25 per month and gives access to design unlimited number of prototypes, the team version which costs \$99 per month, gives access to design unlimited number of prototypes and allows sharing of mockups with up to 5 team members. The last version is the enterprise version which gives access to design unlimited prototypes, allows sharing with multiple team members, live sharing (number of participants that can be invited to

in-browser design collaboration, includes toll-free voice call) and has a 7-day trial period.

2. Marvel: This tool has 3 versions. The free version which gives access to design 2 projects and allows only one user, the Pro version which costs \$15 per month, allows only one user, and gives access to design unlimited number of prototypes, download prototypes, password protect prototypes and remove Marvel branding. The last version is the Company version which cost \$60 per month, allows at least 4 users (if the number of users increase, the cost per month increases as well), gives access to design unlimited number of prototypes, download prototypes, password protect prototypes, remove Marvel branding and organize users into teams.
3. Justinmind: This tool has 2 versions. The Professional version which costs \$29 per month and gives access to create an unlimited number of prototypes. This Professional version can be evaluated for a 30-day trial period and if it's not upgraded after the trial period the user is automatically switched to a free forever version. The second version is the Enterprise version which gives access to create an unlimited number of prototypes and allows users to install the collaboration server behind their firewall, grants access to user management, allows for publishing of prototypes on remote user testing tools to get meaningful feedback.
4. Fluid UI: This tool has 4 versions. The free forever version which gives access to design 1 project, the Solo version which costs \$15 per month and gives access to design 3 projects, the Pro version which costs \$25 per month and gives access to

design 10 projects. The last version is the Team version which costs \$65 per month and gives access to design unlimited number of projects

- **Usage Platform (what platform does the tool run on?)**

1. InVision: This is a web-based tool
2. Marvel: This is also a web-based tool
3. Justinmind: This tool is available for download and runs on both mac and windows operating systems
4. Fluid UI: This is a cloud-based tool

- **Types of Applications Designed with Tool**

1. InVision: Prototyping tool for designing android, ios and web applications
2. Marvel: Prototyping tool for designing ios, Android and Apple Watch applications
3. Justinmind: Prototyping tool for designing android, ios and web applications
4. Fluid UI: Prototyping tool for designing android, ios, web and desktop applications

- **Demoing**

1. InVision: Allows for mobile skins to be added to frame mobile designs when viewing mobile app designs on a desktop browser. It also allows for mobile app designs to be viewed on mobile devices in 3 ways. The first is by either SMS or emailing a link to open design on the mobile device, the second is by presenting mobile website designs in mobile browsers just like real-life mobile-optimized

websites. Lastly, mobile app designs can be viewed on mobile devices by downloading it as an app.

2. Marvel: Allows prototype designs to be viewed in an offline mode but this is only available for ios apps (offline playback).
3. Justinmind: Allows for the use of URL links to view prototypes. It also allows the sharing and testing of designs which run on real devices.
4. Fluid UI: Allows for online sharing of projects

- **Number of Pages Allowed Per Project for Free version**

1. InVision: Unlimited number of screens.
2. Marvel: Unlimited number of pages.
3. Justinmind: Unlimited number of pages.
4. Fluid UI: Allows only 10 pages

- **Ability to Create Designs and Upload Images**

1. InVision: Does not support creation of designs. Designs must be done within another tool. However, it supports upload of sketches and images in formats such as JPG, GIF and PNG.
2. Marvel: Does not support creating of designs. Designs must be done within another tool. However, it allows for image upload in formats such as JPG, PSD and GIF.
3. Justinmind: Supports the creation of designs and uploads of images.
4. Fluid UI: Supports the creation of designs however, it does not support image uploads for the free version

- **Transition Effects (Animation-like effect when moving from one page to another)**

1. InVision: Supports transition and animation effects.
2. Marvel: Supports transition and animation effects.
3. Justinmind: Supports transition effects and animations.
4. Fluid UI: Supports transition effects and animations.

- **Gestures (swipe, tap, flick, drag, etc.)**

1. InVision: Supports gestures.
2. Marvel: Supports the addition of gestures to screens.
3. Justinmind: Allows mobile gestures to be simulated in mobile apps.
4. Fluid UI: Supports gestures.

- **Built in Library**

1. InVision: Has a comprehensive UI kit which includes over 52 complete design templates, 35 custom icons, and over 180 UI components.
2. Marvel: Does not contain library of widgets however, it supports a feature called “Layers” which allows the adding of elements over the top of screens.
3. Justinmind: Has widget libraries including predesigned icons and templates.
4. Fluid UI: Has a library of wireframes, ios and android widgets.



<b>PROTOTYPING TOOL/ REQUIREMENTS CONSIDERATION</b>	<b>Invision</b>	<b>Marvel</b>	<b>Justinmind</b>	<b>Fluid UI</b>
<b>Learning the tool</b>	Easy	Easy	Not So Easy	Easy
<b>Registration</b>	Short Process	Short Process	Not required	Short Process
<b>Cost</b>	Free version available	Free version available	30-day trial version available	Free version available
<b>Usage Platform</b>	Web-based	Web-based	Downloadable for mac and windows	Cloud-based
<b>Applications Designed with Tool</b>	Android, ios and Web	ios, android and Apple Watch	Android, ios and web	Android, ios, web and desktop
<b>Demoing</b>	View designs on browser or open app link on mobile device or view on mobile browser or download prototype to mobile device	Viewing of prototypes in offline mode (only for ios apps)	Share prototypes on mobile devices or view prototypes using URL	Online sharing of projects
<b>No. of Pages Per Free Version Project</b>	Unlimited	Unlimited	Unlimited	10 pages
<b>Create Designs</b>	Not supported	Not supported	Supported	Supported
<b>Upload of Images</b>	Supported	Supported	Supported	Not supported
<b>Transition Effects and Gestures</b>	Supported	Supported	Supported	Supported
<b>Built in Widgets Library</b>	Has UI kit containing UI components & icons	No widgets library	Has widgets library	Has widgets library

Table 4.1 Summary of market analysis for prototyping tools

After the comparison was done, even though the other three tools came very close in comparison, we decided to design out prototype using the Justinmind tool because it is the only tool on our list that is downloadable thus permitting us to work offline if we so desire.

#### 4.4.2. Architectural Design

We have not implemented the full application for this research, however, we have designed a conceptual architecture showing the various components of the falls management application and how they will interact with each other. The falls management application is a hybrid mobile application i.e. it is installed on the mobile phone, however, some parts of it are rendered in a browser which is embedded within the app.

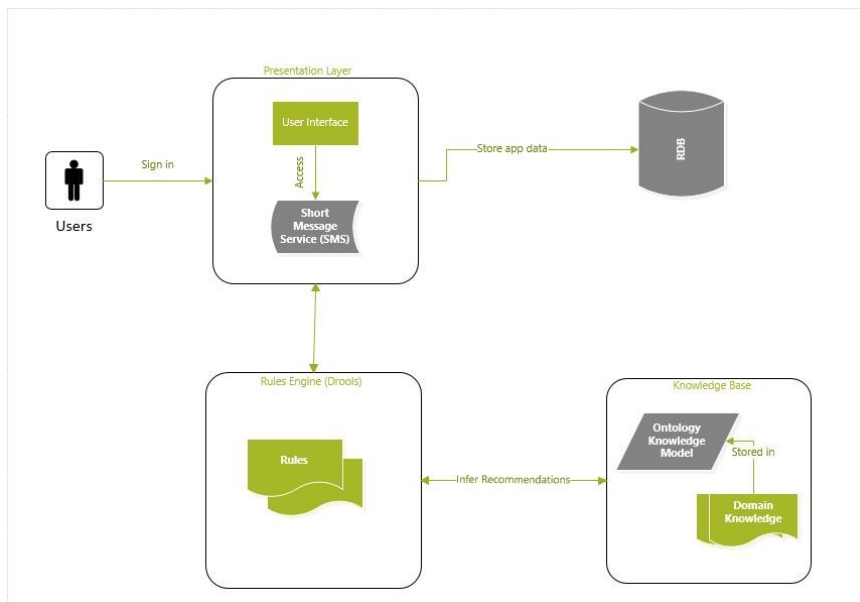


Figure 4.3 Conceptual Architecture of Falls Management App

For future implementation of the app, the app design will have three main components the Presentation Layer, Rules engine which is contained in the Business Rules Management System and the knowledge base.

The presentation layer will feature the User Interface. The Rules engine contains the rules concerning our knowledge domain and thus when a specific rule is fired, a specific recommendation is inferred from the knowledge base. The knowledge will be represented using an ontology model which will contain user specific data. The ontology will be built into a Business Rule Management System (BRMS) as data objects; BRMS such as DROOLS. The DROOLS workbench is an application that provides a generic web user interface for authoring and management of rules and can also be used for testing and deploying the rules. The decision logic for this app is captured and expressed in the form of a decision table (fig 4.2). And the decision table will be built into DROOLS as Guided Rules. The rationale for using an ontology model is:

1. To facilitate and promote reuse of knowledge
2. To separate the domain knowledge from the operational knowledge
3. To enable sharing of the information structure among other individuals
4. Ease of changing domain assumptions if knowledge about the domain changes
5. Improving understanding and communication of knowledge between system designer and developer

When a user signs in to the application, they are taken to the presentation layer. They take the evaluation tests and depending on what their score and frailty category is, a specific rule is fired. An example of such a rule could be:

**IF**

evaluation score is 6 AND frailty category is fifth

**THEN**

user is Mildly Frail and in Blackout Phase.

At this point, the rule engine checks the knowledge base for a recommendation that is associated with Mildly frail individuals in the blackout phase and sends it to the presentation layer to be viewed by the user.

#### **4.4.3. Working of the Mobile App Prototype**

We have designed the app prototype using the Justinmind prototyping tool. We demonstrate workings of the prototype using some of the common scenarios of the falls. The following section show the app's potential in managing falls in the elderly, including information it provides based on the user's level of frailty and patient engagement phase.

##### **Scenario A: User is Physically Well but lacks knowledge about fall management**

Assuming a user who is otherwise physically well, but uninformed about the management of falls, signs in to the application and wants to view the fall management phases. She opens the falls management phases tab and takes the evaluation questions.



Fig 4.4 Scenario A: User taking evaluation questions to unlock phase 1

Based on the options selected by this user from numbers 1 to 4 she gets a score of 4. This means that she or her loved one is in the blackout phase. And because she selected the second option in question 5, it means she is in category 2 (meaning “Well” on the clinical frailty scale). Falls management information for phase 1 will be presented to her as shown in fig 4.5.

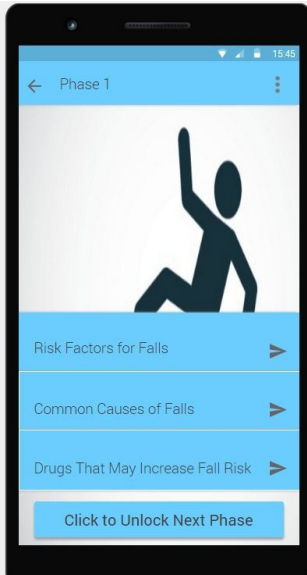


Fig 4.5 Scenario A: Phase 1 unlocked

If she wishes to continue after viewing the fall risk factors, common causes of falls and drugs that may increase fall risk, she will take the evaluation questions again. This is to determine if she is still in the same patient engagement phase or if the information she received has helped to move her to the next patient engagement phase. As seen in this scenario, based on the options this user selected for the evaluation questions 1 to 4, she gets a score of 4 again. This means that she is still in the same phase of patient engagement.

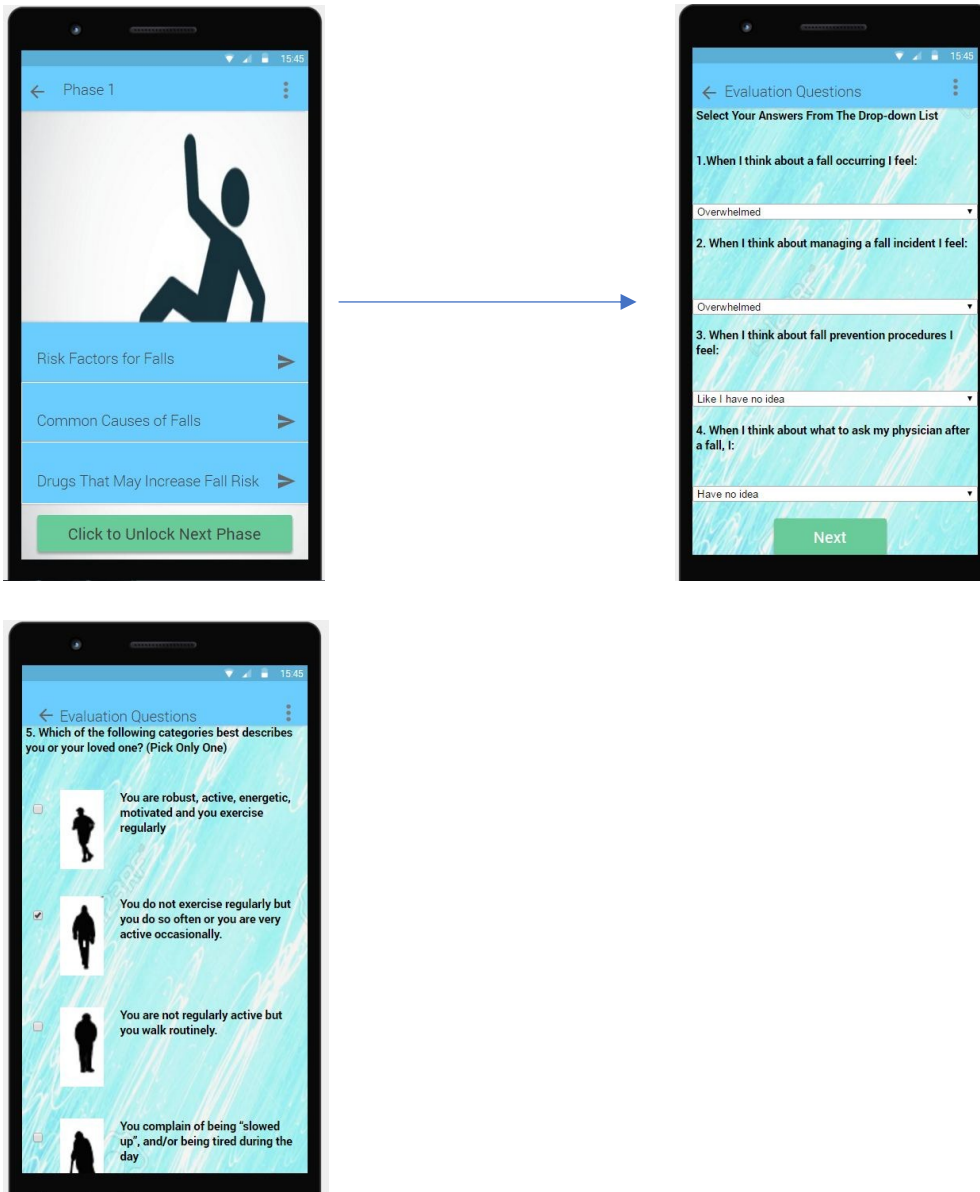


Fig 4.6 Scenario A: User taking evaluation questions to move to phase 2

The app includes a decisional balance exercise that determine positive and negative perceptions of the users when it comes to receiving more knowledge about falls management. The purpose of this exercise is to encourage users to attain more knowledge and gain better understanding of falls management, so that the user can move along to the next phase. The user is redirected to the decisional balance page that contains a list of

statements about fall management. The user is asked to indicate which of the statements she considers as pros and which of them as cons. In this scenario, the user's pros are more than her cons, therefore, she is moved to the next phase of patient engagement.

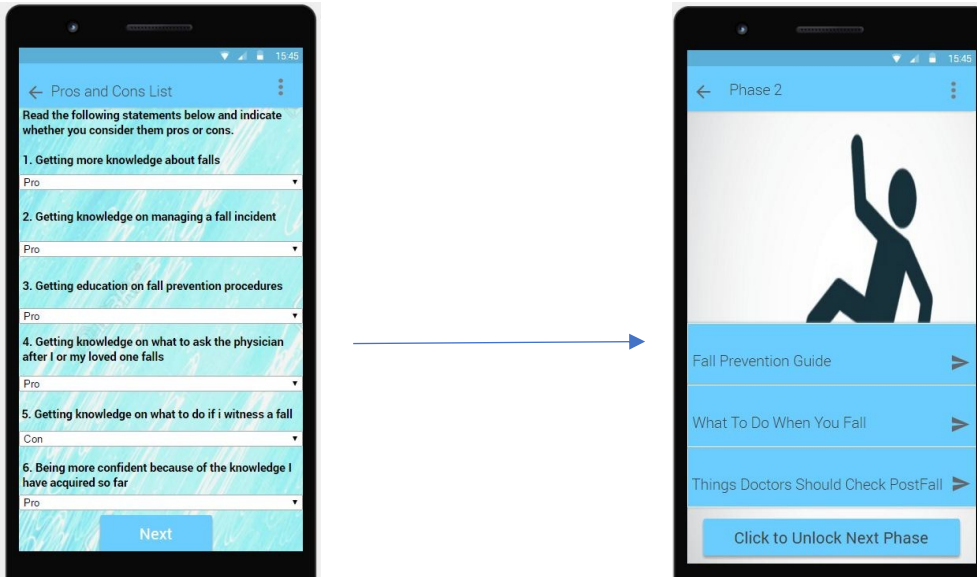


Fig 4.7 Scenario A: User taking pros and cons evaluation to unlock phase 2

It is important to note that when a user unlocks a new phase, there will be pop-up notifications encouraging the user to take enough time (up to a week) to reflect on and absorb the new information from that phase before attempting to move on to the next phase. Once the user feels comfortable to move on to the next phase, she can take the evaluation questions again. This user's options as shown in Fig 4.8 indicates that she gets a score of 12 and that she remains in the same frailty category. At this point she moves to phase 3.



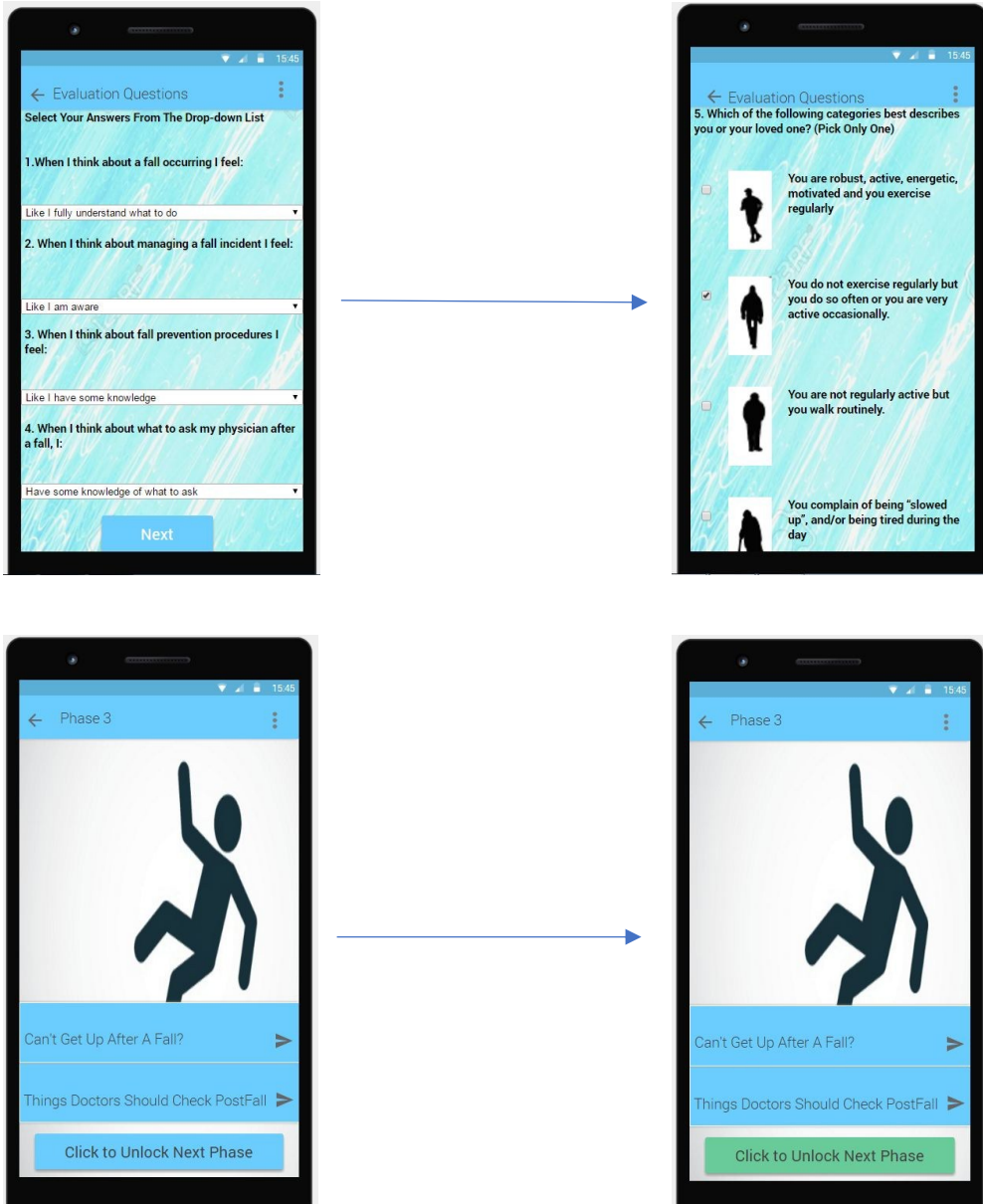


Fig 4.8 Scenario A: User taking evaluation test to unlock phase 3

The user then takes the evaluation questions again and is moved to the last phase as shown in Fig 4 .9.



Fig 4.9 Scenario A: User completes evaluation questions and unlocks phase 4

**Scenario B: User is severely frail and lacks knowledge of the fall management**

Assuming a user, who is severely frail and uninformed about the management of falls, signs in to the application and wants to view the fall management phases. He opens the falls management phases tab and takes the evaluation questions.



Fig 4.10 Scenario B: User taking evaluation questions to unlock phase 1

Based on the options selected by this user from numbers 1 to 4 he gets a score of 4. This means he or his loved one is in the blackout phase. And because he selected the seventh option in question 5, it means that he is in category 7 (meaning “Severely Frail” on the

clinical frailty scale). Falls management information for phase 1 will be presented to him as shown in fig 4.11.

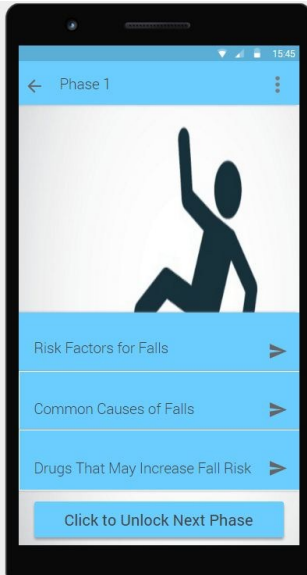


Fig 4.11 Scenario B: Phase 1 unlocked

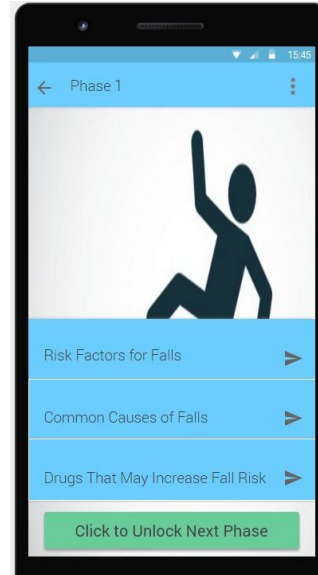


Fig 4.12 Scenario B: User wants to unlock next phase

It is important to note that the falls management information for phase 1 is the same for all categories of frailty and patient engagement phases.

To help determine if he remains in the same phase of patient engagement, he takes the evaluation questions again to unlock the next phase (fig 4.12). In this scenario, the options selected by this user (fig 4.13) gets him a score of 8. This means that he is now in the arousal phase of patient engagement, therefore, he unlocks phase 2 and gets new information as shown in fig 4.14.

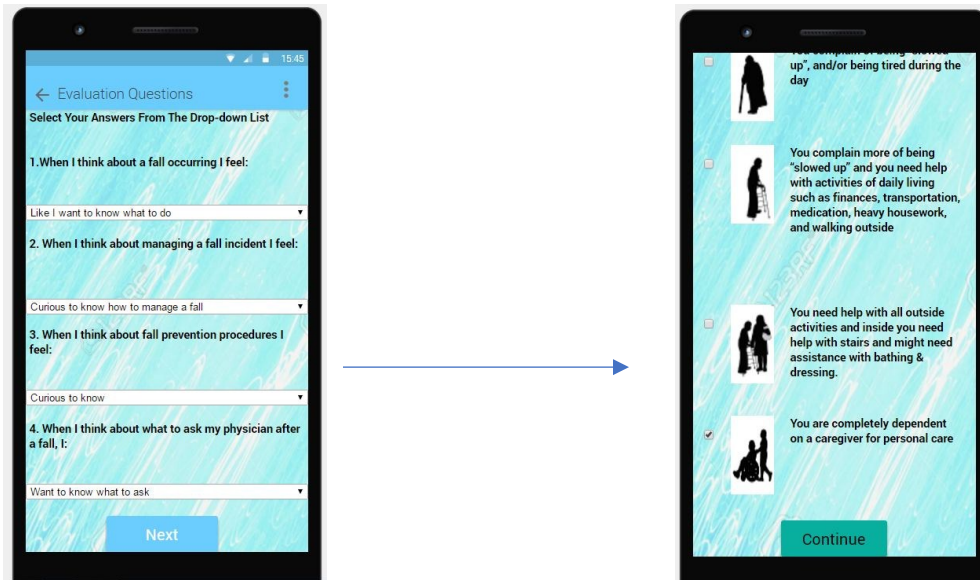


Fig 4.13 Scenario B: User taking evaluation test to unlock phase 2

It should be noted that the information tabs shown in phase 2 of this scenario has some differences from that of scenario A (see fig 4.7). Phase 2 of this scenario shows information on what to do when an individual witnesses a fall. This is because the user selected the frailty category of 7, which is severely frail, meaning that the user may be a caregiver that needs information for a dependent loved one. Therefore, he is provided with the information that a caregiver will need in order to assist his loved one in the event of a fall. From this point, he moves on to the next phase by taking the evaluation questions again as shown in fig 4.14.

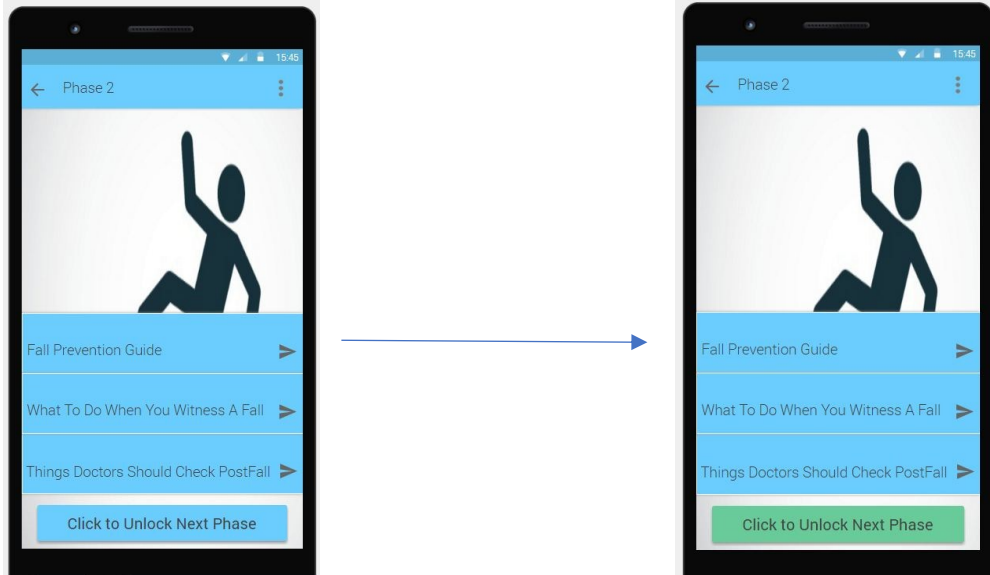


Fig 4.14 Scenario B: User unlocks phase 2.

Fig 4.15 shows that the options he selects get him a score of 12. This means that he is now in the adhesion phase of patient engagement, therefore, he unlocks phase 3 and gets new information. The tabs shown in phase 3 of this scenario also has some differences from that of scenario A (see fig 4.8). When the user needs to move to the next phase, he takes the evaluation questions again as shown in fig 4.15 when he clicks the “Click to Unlock Next Phase” tab.

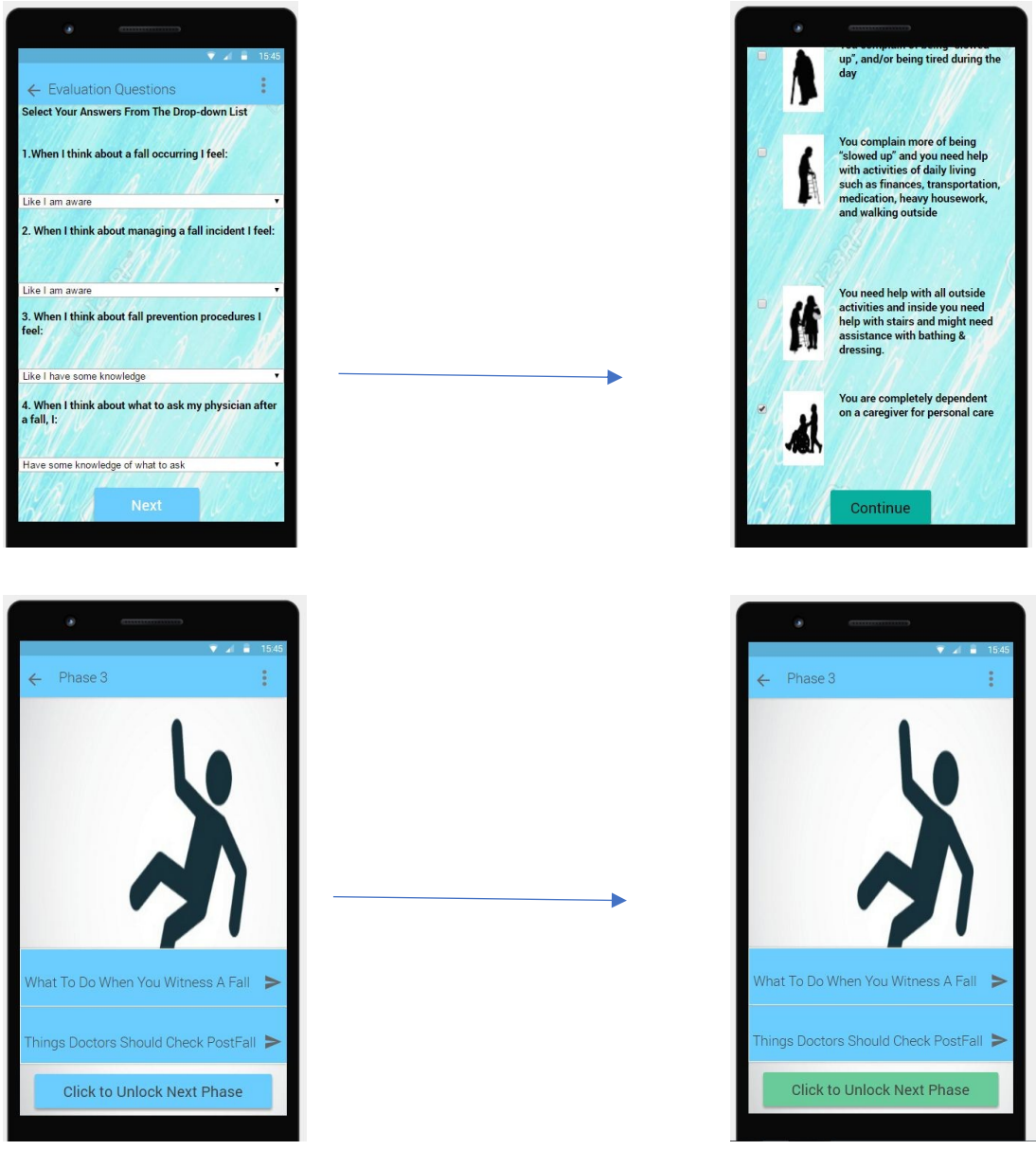


Fig 4.15 Scenario B: User takes evaluation questions to unlock phase 3

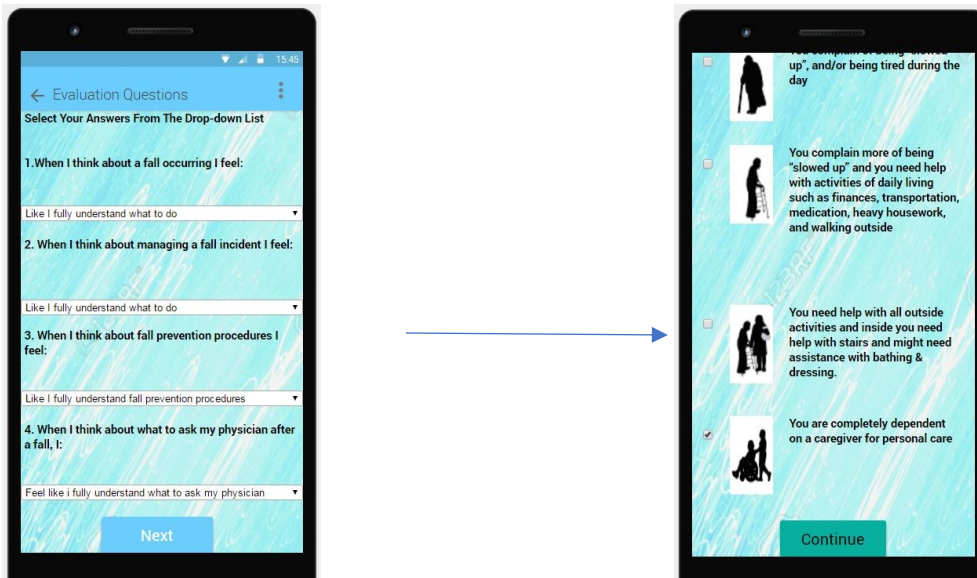


Fig 4.16 Scenario B: User takes evaluation questions to unlock phase 4.

Fig 4.16 shows that the options he selects gets him a score of 16. This means that he is now in the eudaimonic project phase of patient engagement, therefore, he unlocks phase 4 (fig 4.17) and gets new information. Again, the tab shown in phase 4 of this scenario is different from that of scenario A (see fig 4.9).



Fig 4.17 Scenario B: Phase 4 unlocked



## 4.5. Mobile Application Evaluation

Providing personalized educational falls management information to the elderly/caregivers which is based on evidence-based theories that focus on improving and sustaining patient and caregiver engagement is a novel approach to healthcare. Therefore, the falls management application was assessed through a usability evaluation study.

### 4.5.1. Study Design

Ethics approval (REB# 2017-4159) was received from the Dalhousie Research Ethics Board prior to the commencement of this mix-method usability study. The purpose of this evaluation study was to gain end-user feedback on the ease of use of the app interface, the usefulness and suitability of the content when it comes to managing falls in the elderly, and gain information on any potential modifications required to improve design, content and user experience. Individual meeting sessions were conducted with each participant and each session lasted an hour. Each session consisted of two parts; in the first part users performed a set of tasks designed to assess the application's ease of use, after which they moved to the second part which was a structured interview session.

Study Design	
Study Type	Mix method App usability study and content Testing using survey
Target Population	<ul style="list-style-type: none"><li>• Elderly Individuals above 65-years who can read and communicate verbally in English and are able to provide consent.</li><li>• Unpaid caregivers of older adults</li></ul>

	Study Design
<b>Sample Size</b>	9 participants
<b>Materials Used for Study</b>	A smartphone with wireless internet, Audio recorder
<b>Methods</b>	<p>Each participant completes the two parts of the survey session within a 1 hour period.</p> <ul style="list-style-type: none"> <li>• First Part: Participants are assigned tasks to perform using the app while the survey facilitator observes and answers some questions based on the observations of how participants navigated the app in performing their tasks. This study tasks and questions are based on the tasks and questions used in a cognitive walkthrough process.</li> <li>• Second Part (Structured Interview): Participants are asked questions after using the app while being audio recorded.</li> </ul>
<b>Data Analysis</b>	Both qualitative and quantitative analysis performed.

Table 4.2 – Study Design Summary

#### 4.5.2. Study Sample

This evaluation study was intended to help improve the design, content and user experience of the falls management application by collecting feedback from users.

According to Six & Macefield [2016], there is no one-size-fits-all solution to determining the optimal number of participants for a usability study, however, problem discovery-studies typically require between three and twenty participants with five to ten being a good baseline. Therefore, we recruited 9 participants and they fell into groups of elderly and caregiver participants. There were 5 elderly participants in one group and 4 caregiver participants in the other.

#### **Our inclusion criteria were:**

- Community dwelling male and female older adults who are 65 years or older

- Older adults who are “app savvy”
- Unpaid caregivers who cater to their older family members or friends
- Older adults/caregivers who can read and communicate verbally in English
- Older adults/caregivers who can provide their own consent to be part of the study
- Older adults/caregivers who voluntarily agreed to be part of the study

**Our exclusion criteria were:**

- Older adults/caregivers who are not “app savvy”
- Older adults who live in a long-term care facility
- Older adults/caregivers who do not consent to be part of the study
- Older adults/caregivers who do not live in Halifax

Participants were recruited by placing posters in mailboxes at a senior’s housing complex, and inviting the seniors to contact us if they were interested in volunteering for the study. Individuals who indicated interest in being part of the study, were asked 4 simple yes/no screening questions to determine how ‘app savvy’ they are. Table 4.3 shows the questions that were used to determine “app savvy-ness”.

<b>Questions 1</b>	Do you use a smartphone?
<b>Questions 2</b>	Do you know what an app is?
<b>Questions 3</b>	Have you ever used an app?
<b>Questions 4</b>	Do you feel comfortable using a new app?

Table 4.3 Questions to determine “app savvy-ness”

Only individuals who answered in the affirmative to all 4 questions were deemed app savvy and recruited for the study. “App savvy-ness” was considered to ensure that individuals who were recruited for the study were able to meaningfully engage in using the application and give meaningful feedback. Snowball sampling was applied in recruiting participants as recruited participants were asked to contact any of their acquaintances who they know might be interested in being part of the study, and recruitment continued in this manner until the desired number of participants was attained.

#### **4.5.3. Procedure**

Paper based informed consent forms were signed by participants after they were administered the informed consent. After participants signed the informed consent forms, users commenced the first part of the evaluation session. This first part of the evaluation session was used to test the ease of use of the app interface and users were assigned tasks to perform using the falls management application. While users performed their tasks, the study facilitator observed and answered some questions based on how participants navigated the application in performing their assigned tasks. These tasks and questions are based on the tasks and questions used in a cognitive walkthrough process. Cognitive walkthrough is used to test the usability of interactive software [Wharton et al, 1994]. It is an interface evaluation technique which focuses on the support the interface offers to exploratory learning i.e., usage with no previous training [Rieman et al, 1995]. The cognitive walkthrough aims to simulate the steps taken by a user with no previous experience with an (application) interface [Campos & Mano, 2006]. It was developed as an additional tool in usability engineering, to give design teams a chance to evaluate early

mockups of designs quickly. It doesn't require a fully functioning prototype, and it helps designers to take on a potential user's perspective and therefore identify some of the problems that might arise in interactions with the system [Campos & Mano, 2006]. The cognitive walkthrough is a practical evaluation technique grounded in Lewis and Polson's CE+ theory of exploratory learning [Lewis et al, 1993 & Polson et al, 1992]. The CE+ theory is an information processing model of human cognition that describes human-computer interaction in terms four steps: 1) The user sets a goal to be accomplished with the system, 2) The user searches the interface for currently available actions, 3) The user selects the action that seems likely to make progress toward the goal, 4) The user performs the selected action and evaluates the system's feedback for evidence that progress is being made toward the current goal [Campos & Mano, 2006].

Before starting the first part of the evaluation session, participants were evaluated to test what phase of patient engagement and what category of frailty they belonged. After this step, participants were assigned simple tasks as shown in table 4.4, to perform using the app. As participants carried out their assigned tasks, we observed their use of the application and answered four questions which were adapted from the questions used in a cognitive walkthrough [Abowd, 1995], based on our observation of how participants navigated the app in performing their tasks. After the first part of the evaluation session, a post study structured interview session was immediately carried out on participants. The interview questions consisted of five close ended and nine open ended questions which was validated by the domain expert on our advisory panel. We developed these interview questions to get user feedback on the suitability and usefulness of the app content to our target population. It contained questions that tested user's knowledge about falls

management such as safe responses to fall incidents, fall prevention tips and factors that could increase fall risks. It also contained questions that solicited what users would feel having the application on their personal smartphones.

<b>Task 1</b>	Using the app can you tell me some common causes of falls
<b>Task 2</b>	Using the app can you tell me what drugs increase your risk of falling?
<b>Task 3</b>	Using the app can you read the fall prevention guide to me?
<b>Task 4</b>	Using the app can you tell me what you should do when you fall? / Using the app can you tell me what you should do when you witness a fall?
<b>Task 5</b>	Using the app can you tell me what you should do when you can't get up after a fall? / Using the app can you tell me what you should do when your loved can't get up after a fall?
<b>Task 6</b>	Using the app can you tell me some things your doctor can check after you have had a fall? / Using the app can you tell me some things the doctor can check after your loved one has had a fall?

Table 4.4 User Tasks Performed During First Part of the Evaluation Session

#### 4.5.4. Data Collection

The study captured both quantitative and qualitative data for analyses.

The study utilized individual meeting sessions and the **quantitative** data was collected at two points during the individual meeting sessions. Quantitative data was first collected during the first part of the evaluation session, when we assigned yes/no responses to the

questions we adapted from the cognitive walkthrough process as we observed the users' navigation of the application while they performed each task. These responses were recorded on paper. Quantitative data was also collected using the five close-ended questions from the post study structured interview questions that solicited yes/no responses from participants.

## CHAPTER 5: DATA ANALYSIS AND RESULTS

The study captured both quantitative and qualitative data to thoroughly evaluate the falls management application. The quantitative data collected from the first part of the evaluation session gave a general perception of the application's usability. While the quantitative and qualitative data collected from the post study structured interview gave a general idea of the application content's suitability and usefulness to users. The qualitative data also helped identify areas for improvement of the falls management application.

### 5.1. Quantitative Analysis

The quantitative data collected from the first part of the evaluation session included yes/no responses we assigned to the four questions adapted from the cognitive walkthrough process [Abowd, 1995] shown in table 5.1 as we observed the users' navigation of the application while they performed each task. Participants were expected to carry out certain actions per task assigned. Analysis was performed first on individual participant level and then on the two groups of participants (elderly and caregivers) based on the different tasks. This was to objectively evaluate the usability of the application.

<b>Question 1</b>	Is the action taken what the participant wants to do?
<b>Question 2</b>	Once the participant knows what they should do, is the action visible to them?
<b>Question 3</b>	Do participants recognize actions as correct ones?
<b>Question 4</b>	Do participants understand the information the app provides them at the end of their given tasks?

Table 5.1 Questions Adapted from the Cognitive Walkthrough Process



Table 5.2 shows the responses for an elderly user searching for the common causes of falls (Task 1) using the application. The user was expected to perform the following actions to complete their task:

- Action a: Go to phase 1
- Action b: Look for tab which reads common causes of falls and click the forward arrow
- Action c: Scroll down to read all information given

**Adapted Questions**

<i>Actions</i>	1)	2)	3)	4)
<i>Action a</i>	Yes	Yes	Yes	Yes
<i>Action b</i>	No	Yes	Yes	Yes
<i>Action c</i>	Yes	Yes	Yes	Yes

Table 5.2 Summary for Task1 for an Elderly Participant

Table 5.3 shows the responses for an elderly user searching for what to do when a fall occurs (Task 4) using the application. The user was expected to perform the following actions to complete their task:

- Action a: Go to phase 2
- Action b: Look for tab which reads what to do when you fall and click the forward arrow
- Action c: Scroll down to read all information given

### Adapted Questions

<i>Actions</i>	1)	2)	3)	4)
<i>Action a</i>	Yes	Yes	Yes	Yes
<i>Action b</i>	Yes	Yes	Yes	Yes
<i>Action c</i>	Yes	Yes	Yes	Yes

Table 5.3 Summary for Task4 for an Elderly Participant

Table 5.4 shows the responses for an elderly searching for what to do when they can't get up after a fall using the application (Task 5). The user was expected to perform the following actions to complete their task:

- Action a: Go to phase 3
- Action b: Look for tab which reads can't get up after a fall? and click the forward arrow
- Action c: Scroll down to read all information given

### Adapted Questions

<i>Actions</i>	1)	2)	3)	4)
<i>Action a</i>	Yes	Yes	Yes	Yes
<i>Action b</i>	Yes	Yes	Yes	Yes
<i>Action c</i>	Yes	Yes	Yes	Yes

Table 5.4 Summary for Task5 for an Elderly Participant

Table 5.5 shows the responses for an unpaid caregiver searching for the common causes of falls (Task 1) using the application. The user was expected to perform the following actions to complete their task:

- Action a: Go to phase 1
- Action b: Look for tab which reads common causes of falls and click the forward arrow
- Action c: Scroll down to read all information given

**Adapted Questions**

<i>Actions</i>	1)	2)	3)	4)
<i>Action a</i>	Yes	Yes	Yes	Yes
<i>Action b</i>	Yes	Yes	Yes	Yes
<i>Action c</i>	Yes	Yes	Yes	Yes

Table 5.5 Summary for Task1 for an Unpaid Caregiver

Table 5.6 shows the responses for an unpaid caregiver searching for what to do when they witness a fall (Task 4), using the application occurs. The user was expected to perform the following actions to complete their task:

- Action a: Go to phase 4
- Action b: Look for tab which reads after you witness a fall and click the forward arrow
- Action c: Read and answer Yes or No to questions

**Adapted Questions**

<i>Actions</i>	1)	2)	3)	4)
<i>Action a</i>	Yes	Yes	Yes	Yes
<i>Action b</i>	Yes	Yes	Yes	Yes
<i>Action c</i>	Yes	Yes	Yes	Yes

Table 5.6 Summary for Task4 for an Unpaid Caregiver

Table 5.7 shows a summary of all the elderly participants' execution of task 1 (searching for the common causes of falls). In total, there were 5 elderly participants. They all completed actions a and c perfectly without any help. But for action b, one elderly participant required some help to complete this action, while the other four elderly participant completed this action without help.

	<b>Action a</b>	<b>Action b</b>	<b>Action C</b>
<i>Not completed</i>	-	-	-
<i>Completed</i>	5	4	5
<i>Completed with help</i>	-	1	-
<i>Completed with Failures</i>	-	-	-

Table 5.7 Execution of Task1 for all Elderly Participants

Table 5.8 shows a summary of all the elderly participants' execution of task 4 (searching for what to do when a fall occurs). They all completed actions a, b and c perfectly without any help.

	<b>Action a</b>	<b>Action b</b>	<b>Action C</b>
<i>Not completed</i>	-	-	-
<i>Completed</i>	5	5	5
<i>Completed with help</i>	-	-	-
<i>Completed with Failures</i>	-	-	-

Table 5.8 Execution of Task4 for all Elderly Participants

Except for one elderly participant who could not complete task 1 action b without help, all the other elderly participants performed their assigned tasks without any help.

For the unpaid caregivers, they did not need any help completing all their tasks. Table 5.9 shows a summary of all the unpaid caregivers' execution of task1 (searching for the common causes of falls).

	Action a	Action b	Action C
<i>Not completed</i>	-	-	-
<i>Completed</i>	4	4	4
<i>Completed with help</i>	-	-	-
<i>Completed with Failures</i>	-	-	-

Table 5.9 Execution of Task1 for all Unpaid Caregivers

The elderly participant who found it difficult to complete one task without help had difficulties clicking on the forward arrow to move the app to the next page. This was a very important observation which will lead to an improved version of the app when it is being implemented. The first part of the evaluation session was a good source of identifying usability problems associated with the falls management app interface. Based on the results of the entire first part of the evaluation session, the app was easy for both caregivers and the elderly participants to use and navigate through.

The quantitative data that gave a perception of the application content's suitability and usefulness was collected from the post study structured interview session. It solicited yes/no responses from the users. The questions tested users' awareness about safe falls management practices. In the next phase of qualitative data collection, users were asked to give specific details about safe falls management practices. The purpose of these questions was to determine how much information about safe falls management practices

users have and how much of these practices were actually safe and correct. And this information helped us determine whether our falls management application contained useful and suitable information for the users.

Quantitative analysis for application content's suitability and usefulness was performed using SPSS statistics software.

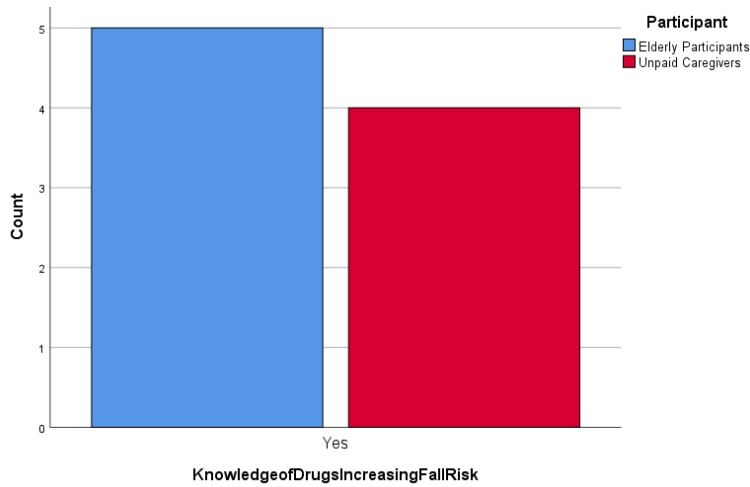


Figure 5.1 Graph showing Participants' Response to Their Knowledge of Drugs That Can Increase the Risk of Falling

Figure 5.1 shows that all the elderly participants and unpaid caregivers responded in the affirmative to having knowledge of drugs that can increase the risk of falling. When asked if they had a fall prevention guide, all participants except one answered in the negative as shown in figure 5.2.

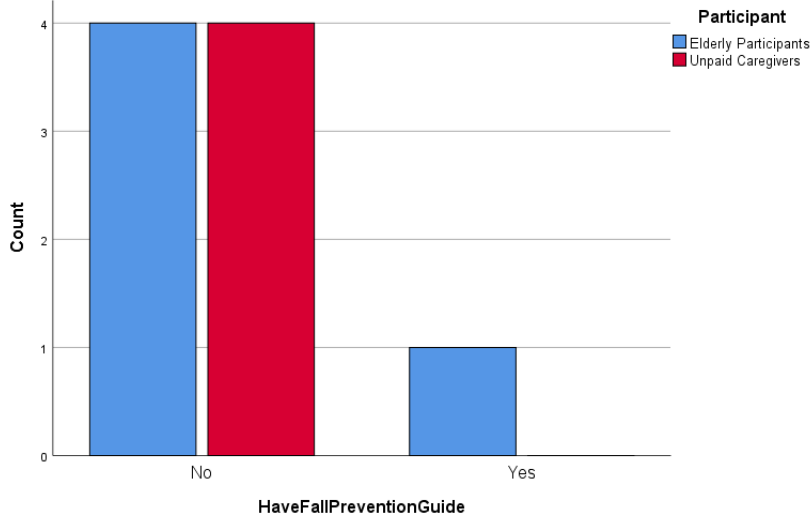


Figure 5.2 Graph showing Participants’ Response to Having a Fall Prevention Guide

Responses to questions about knowledge on how to safely get off the floor after a fall or how to safely help loved ones get off the floor after a fall were solicited, and table 5.10 shows the responses given by participants (elderly participants and unpaid caregivers respectively). All participants except one unpaid caregiver responded in the affirmative.

	<i>Elderly Participants</i>	<i>Unpaid Caregivers</i>
	Safely Get Off Floor Post Fall?	Safely Help Loved One Off Floor Post Fall?
<i>Yes</i>	5	3
<i>No</i>	0	1
<i>Total</i>	5	4

Table 5.10 Participants’ Response to Being Able to Get Off the Floor Safely/Help Their Loved Ones Safely Off the Floor

To determine if participants knew what to do when they can’t get up after a fall or when their loved ones are injured, the questions in Table 5.11 were asked and all participants responded in the affirmative.

	<i>Elderly Participants</i>	<i>Unpaid Caregivers</i>
	Know What to Do When You Can't Get up From a Fall?	Know What to Do When Loved One is Injured?
<i>Yes</i>	5	4
<i>No</i>	0	0
<i>Total</i>	5	4

Table 5.11 Participants' Response to Knowing What to Do When They Can't Get up From a Fall/When Loved One is Injured

Lastly, responses to questions about knowledge on what to ask a doctor to check after participants or their loved ones have had a fall were solicited, and table 5.12 shows the responses given by participants (elderly participants and unpaid caregivers respectively). All participants responded in the affirmative.

	<i>Elderly Participants</i>	<i>Unpaid Caregivers</i>
	Know What to Ask Doctor to Check Post Fall?	Know What to Ask Doctor to Check on Loved One Post Fall?
<i>Yes</i>	5	4
<i>No</i>	0	0
<i>Total</i>	5	4

Table 5.12 Participants' Response to Knowing What to Ask Doctor to Check After They/Their Loved One Falls



## **5.2. Qualitative Analysis**

This study captured qualitative data using post-study structured interview questions. Participants answered nine open-ended questions on specific details about falls management practices and their perception of the application usage (see appendix G and H for question sample). Their answers were audio-recorded using the AudioNBK Free software, version 2.5 (Qrayon, LLC - <http://www.qrayon.com/home/AudioNotebook/>). These open-ended questions were used to determine the usefulness of the app content to our target population and how well the contents of the app will serve as an educational tool for them. The qualitative data was transcribed, imported and analyzed using the qualitative analysis tool, Atlas.ti. Open coding was performed to build a comprehensive code list. Open coding involves reading through a text, interpreting the text and creating a concept that represents what has been read from that segment of the text. It is an inductive way of coding that requires some level of translation on the part of the analyzer i.e. translating what is read into a concept [Contreras, 2013]. After open coding was performed, the frequency of each code was reviewed to identify the most common feedback (Figure 5.3). In this study, any feedback that had a frequency of 3 and above was considered common.

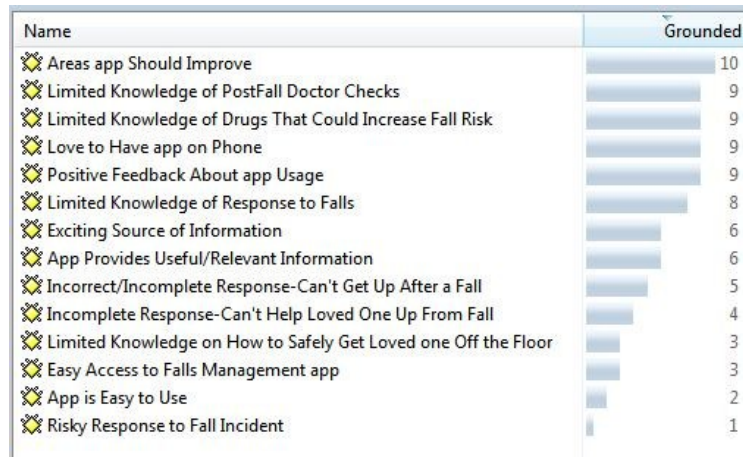


Figure 5.3 Participant Feedback by Frequency

After reviewing the feedback of survey participants, a network view of each code was performed to get a pictorial representation of how the participant quotes connect to the codes. After which axial coding was performed to link the open codes and generate categories. The generated categories are discussed further in the following sub-sections.

### 5.2.1. Knowledge of Fall Incident Management

For this study, knowledge of fall incident management has been generated as a category to help better show participants' responses to various fall incident related questions. From figure 5.4, we gather that participants had some knowledge of fall incident management, however, this knowledge is very limited. For example, participants had limited knowledge regarding what to do when they can't get up after a fall, or when they can't help their loved ones up after a fall. Figure 5.3, shows the frequency of participants' quotes and it can be clearly seen that the frequency or "groundedness" of quotes for "limited knowledge on how to safely get loved one off the floor", "incomplete response-

can't help loved one up from fall", "limited knowledge of response to falls", and "incorrect/incomplete response-can't get up after a fall" are quite high.

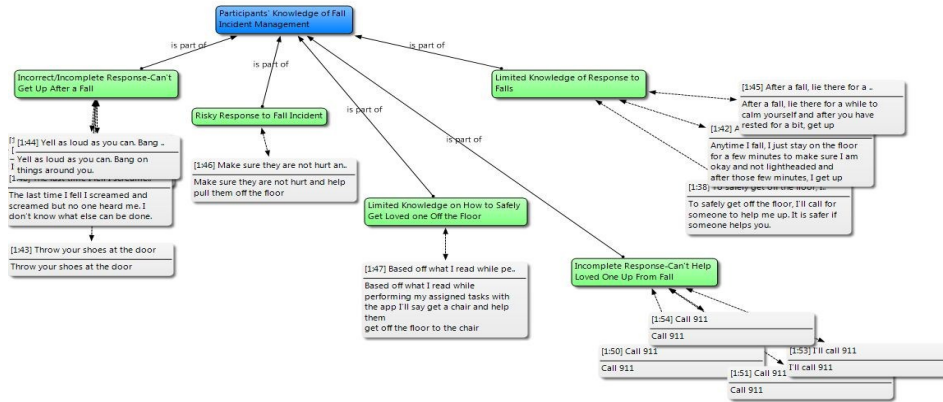


Figure 5.4 Semantic Network Showing Participants' Knowledge of Fall Incident Management

Participant p1	<i>I'll Yell</i>
Participant p2	<i>Bang on the walls</i>
Participant p3	<i>The last time I fell I screamed and screamed but no one heard me. I don't know what else can be done.</i>
Participant p4	<i>Throw your shoes at the door</i>
Participant p5	<i>Yell as loud as you can. Bang on things around you.</i>

Table 5.13 Elderly Participants' Response to When They Can't Get Up After a Fall

As shown in Table 5.13 when an individual can't get up after a fall, participant's p4's response was: *throw your shoes at the door*. Participant p5 responded by saying: *yell as loud as you can*. This participant got it partly right, however, the app shows that there are some other steps to be taken which is crucial to keeping individuals who have fallen safer while they wait for help to arrive. All caregivers were asked what they would do if they

can't help their loved ones get off the floor after a fall. They all responded by saying: *call 911* which is partly right, however, the app shows some other important actions that should be taken to ensure their loved ones are safer and do not get even more hurt while they wait for help. For example, administering first aid if they can do so, keeping their loved one comfortable, and keeping them warm with a blanket. This is a very important step because as seen in the first chapter, remaining on the floor after a fall could result in pneumonia and several other complications, therefore, having the caregivers take these extra actions could help minimize some of these complications.

### **5.2.2. Knowledge of Fall Prevention & Post Fall Doctor Check**

This category was generated to help show Participants' Knowledge of fall prevention and what things they could ask their physicians/loved one's physicians to check after a fall. Most of their responses to things/areas they will ask their physicians to check after fall ranged from x-rays to CAT scans, blood pressure and head examinations. Although these are good responses, there are several other areas physicians can check after a fall that was not mentioned by any of the participants. To help prevent and reduce the risk of falls, the structured interview featured questions to determine participants' knowledge of drugs that could increase fall risk. And the responses given by participants showed that they had little to no knowledge of drugs that could increase their loved ones or their risk of falling. Some excerpts follow:

**Participant p1:** *I know having vertigo increases your risk of falling but I do not know of any drugs that will increase your risk of falling.*

**Participant p2:** *I know some drugs can increase my risk of falling but I can't seem to remember any right now.*

**Participant p3:** *Taking too much of any drug can make you unbalanced.*

**Participant p4:** *Taking too much of a drug can increase the risk of falling because it will make you drowsy.*

**Participant p5:** *I know that when you take too much alcohol it could increase your risk of falling.*

**Participant p6:** *One I can think of right now is caffeine. It makes my loved one jittery. That could increase their risk of falling.*

**Participant p7:** *Excessive intake of sleeping pills can make them feel drowsy for prolonged periods and could lead to falls.*

**Participant p9:** *NSAIDs, any drugs that cause drowsiness or loss of vision and lack of vitamin B.*

It should be noted that participant p9 agreed to the fact that they mentioned NSAIDs because they remembered reading it while using the app to perform the assigned tasks.

### **5.2.3. Positive Feedback About app Usage**

Figure 5.5 shows some quotations of participants on their usage of the app. The frequency of quotations for participants who would love to have the app on their mobile phones (Figure 5.3) was 9. The frequency of quotations for easy access to fall management information was 3, frequency for app's provision of useful/relevant

information was 6 and the frequency for app being an exciting source of information was 6.

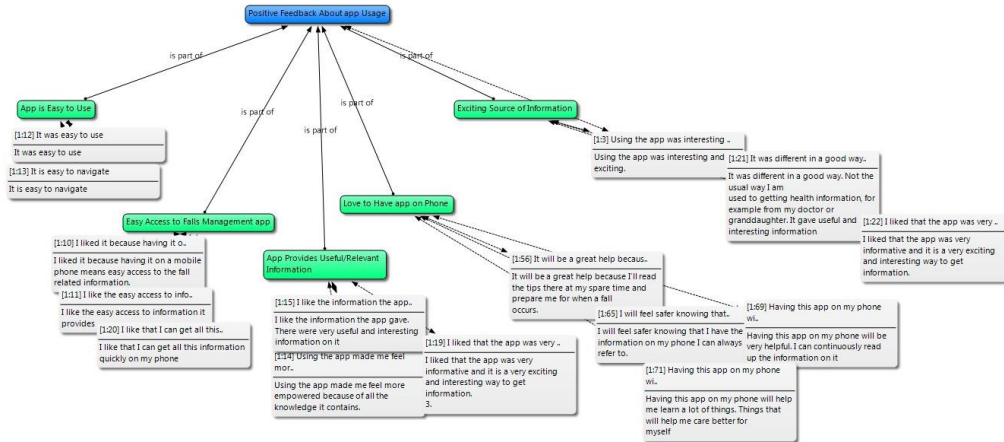


Figure 5.5 Semantic Network Showing Participants' Positive Feedback About app Usage

This feedback shows that the participants liked the app and found the information it provided very useful to them.

#### 5.2.4. Areas for app Improvement

The last category we generated from participants' responses is on the app improvement. Participants' gave valuable feedback on areas which the falls management app could be better. Some excerpts follow:

**Participant p3:** *The print could be bigger. Maybe adding audio to the app so it can read out the information to me.*

**Participant p5:** *I did not like the print size. I wish the prints were larger to make it easier to read.*

**Participant p6:** *I will add some audio functionality to the app so it can read out the app contents to me. I will also add sharing capabilities so I can share some information with my siblings or friends.*

**Participant p7:** *Some of the pages had too much information on them. I think you might want to breakdown or spread out some of the information*

**Participant p8:** *I wish some of the information will be arranged as a drop-down menu so I do not have to go back and forth so much.*

Overall, there was no suggestion acquired from the study that cannot be implemented to improve the falls management app. All suggestions are achievable and will be implemented in the next version of the app.

An interesting observation from the study is the fact that almost all participants answered the quantitative questions in the affirmative but when asked follow-up open-ended questions, it was shown that their knowledge on the subject is quite limited. For example, when asked if they know what to ask the doctor to check after a fall, they all answered “Yes”. However, when they were asked to give details they could only give little details. The study brought to light that there is a huge gap between what elderly individuals and unpaid caregivers claim to know and what they actually know about falls and falls management. With falls being the leading cause of injury-related hospitalizations among seniors in Canada [PHAC, 2014], it is imperative that this gap be bridged. The evaluation seems to indicate that the app may be a good initiative to help educate unpaid caregivers and elderly individuals about falls management thus bridging this observed knowledge gap. The evaluation also showed that the app served as a source of empowerment for its

users as they expressed that having the app on their personal smartphones will make them feel empowered and make them feel safer as the falls management app will give them a better understanding on what to do when a fall occurs. They also expressed that having the falls management app on their smartphone will help increase their confidence about handling falls because all the information they need will all be readily available. Here is an excerpt from participant p7: *Having this app on my phone will make me feel more secure and increase my confidence about handling falls. Because I'll have all this fall management information right here at my fingertips that I can utilize should my loved one experience a fall. It will be a guide for fall prevention, I can always refer to the app to get the information should I forget some steps.* Participant p1 also had this to say: *It was very informative and different. It was different in a good way. Not the usual way I am used to getting health information, for example from my doctor or granddaughter. It gave useful and interesting information. I liked that the app was very informative and it is a very exciting and interesting way to get information.* With our study participants expressing feelings of empowerment, excitement, safety, increase in knowledge about falls and confidence from using the app, it is evident and apparent that our falls management app content is useful and suitable to our target population.



## CHAPTER 6: DISCUSSION AND LIMITATIONS

The interdisciplinary work presented in this research shows that providing personalized fall management information on easily accessible devices such as smartphones serves to keep patients engaged in learning better ways to care for themselves when falls occur. Previous work has studied fall detection and prevention interventions but this novel study offers more functionalities than just prevention of falls. In this study, we have used evidence based theories to personalize educational materials to older adults/caregivers about post fall procedures that could reduce health risks, sustain and improve patient/caregiver engagement. Using theories that personalize educational falls information, improve and sustain engagement within a single design is an innovative approach to falls management. As this is a way to help users better manage fall incidents while considering the user's fall situation and providing relevant information. The study affirmed that users were receptive to the use of an application that provides personalized falls management information and they were highly engaged in the use of the application. During the application assessment phase, participants enjoyed using the app so much so that they suggested adding extra features to the app, such as voice readers and sharing capabilities to share useful tips with their friends and associates.

Also, our qualitative analysis revealed that patients might not always report when they experience falls. Patients reported that when they fall, they try to get up as quickly as possible and they do not always tell their loved ones if they can help it. It is therefore imperative that the use of falls management application be explored in diverse settings such as retirement facilities, nursing homes, etc., to help keep older adults safer and reduce health risks that could result from falls.

## **6.1. Limitations**

One limiting facet of the falls management application prototype is that it is standalone, it is not integrated with patient health records or emergency services.

There was also a limitation to using a prototype for testing and evaluation of the app. For example, the logic rules could not be coded into the prototyping tool which made the evaluation of participants' category of frailty and patient engagement phase a task for the study facilitator to determine manually after participants took the evaluation test. This actually resulted in participant complaints about having to tap back and forth so much. If the logic rules were functional in the app, after participant evaluation, they will be automatically redirected to their personalized fall management information pages instead of having to navigate there manually

With the different mobile phone platforms, available on the market, it was quite a challenge trying to decide which specific type of smartphone the application should be design for. We eventually decided to design the application for android phones because we use android phones and we are used to the android interface.

There were also limits of research ethics restriction. The study was not approved to recruit participants who are not app-savvy. This was because it was expressed that users who are not app-savvy may not be able to meaningfully engage with using the application. Therefore, the user perspective on ease of use for “non-app-savvy” individuals was not determined in the study. Perhaps other design issue may have been revealed if the application was also assessed on non-app-savvy users.

Another limitation is that our design excludes some higher levels of frailty. Therefore, this study cannot determine the ease of use, usefulness and suitability of the application

for individuals who could not recover even from minor illness and are approaching the end of life (with a life expectancy of < 6 months).

## CHAPTER 7: FUTURE WORK

In future, the rich feedback received from the analysis will be incorporated into the falls management app. A voice interaction API will be implemented so that users can perform actions by voice and better communicate with the application. A multi-device usable version of the application will also be implemented. And an efficacy evaluation will be performed on the fully functional application to assess patient/caregiver engagement to the use of the application for falls management.

A future design can also be integrated with patient health records to broaden the application's accessibility to patients and caregivers. The application could have a provider interface as well which can exchange data with the patient interface.

Falls management application can be integrated with emergency services if desired as this will give them access to up to date information that they can easily access in time and seamlessly provide the right information for the right situation.

The falls management application can also be integrated with the remote monitoring components of the Caring Near and Far Study such that when a fall incident occurs, the right information for the specific situation is readily available to caregivers, which will further help improve real-time decision making, improve patient safety and support older adults in safely remaining in their homes.

The approach used for designing this falls management application can be used as a framework to design educational applications for other conditions associated with the elderly such as substance abuse, obesity and oral health.

## CHAPTER 8: CONCLUSION

This study notably developed and evaluated the falls management application that was designed utilizing evidence based theories for information personalization and patient/caregiver engagement. The research combined a frailty index and patient engagement model in one design. It computerized falls management practices to provide personalized information to the elderly and caregivers based on their levels of frailty, the type of fall they have i.e. whether they sustain any injuries or not and whether the fall was witnessed or not. The study shows that using evidence based theories proves to be successful in providing personalized educational information to users and keeping them engaged, therefore, this research could serve as a framework for other researchers, healthcare providers or patients to teach older adults to learn better ways to care for themselves. This study establishes the fact that older adults are open and receptive to new and innovative ways to educate them on better healthcare practices.

The study also reveals that the objectives of this research have been fulfilled. The falls management app serves as a rich source of highly personalized information to help educate elderly individuals and caregivers on falls and how to appropriately respond to fall incidents, serve as a guide to preventing falls and reducing fall risks. It provides an exciting platform to keep the target population engaged in educating themselves about falls management. The study revealed that the information provided by the falls management application is suitable and useful for both patients and caregivers.

In conclusion, the need for innovative ways to design solutions that will help educate the elderly and their caregivers about falls management and other conditions associated with elderly individuals is limitless. It is therefore our recommendation that the falls

management application be integrated with other health information systems, integrated with remote monitoring components of the Caring Near and Far Study and piloted in several healthcare settings.

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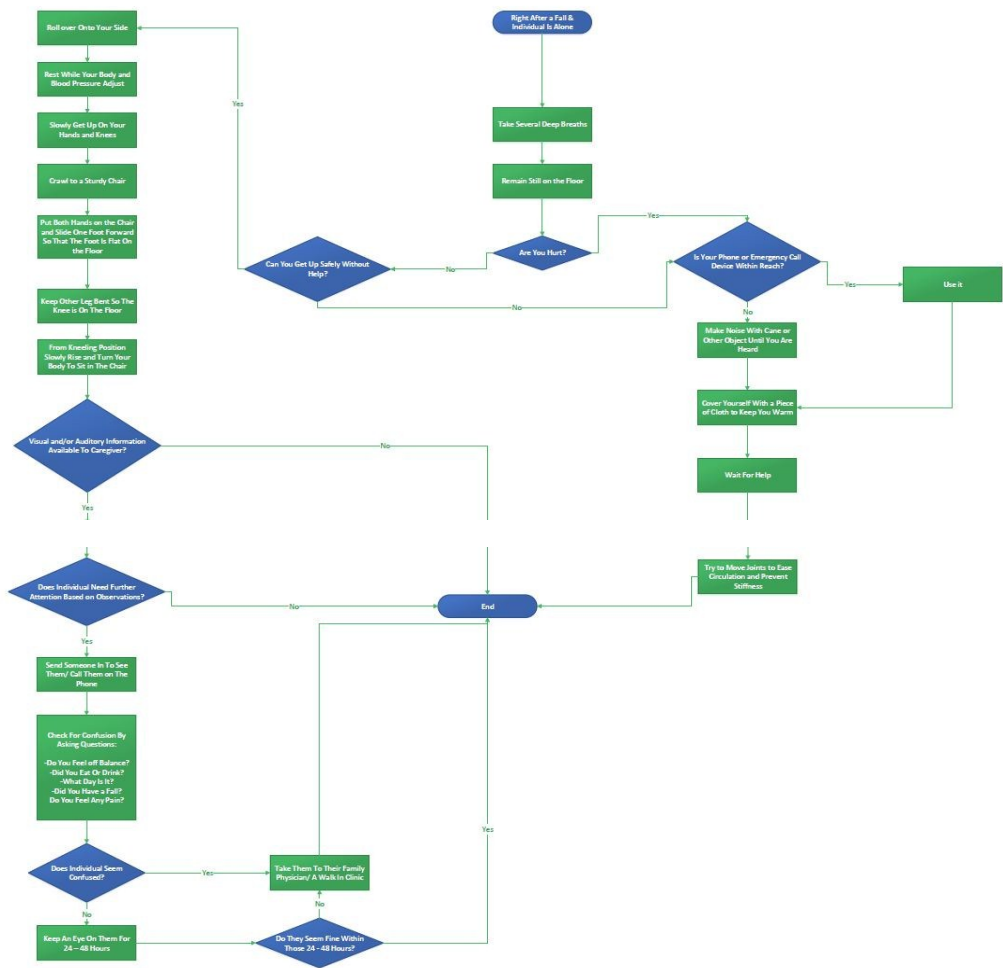
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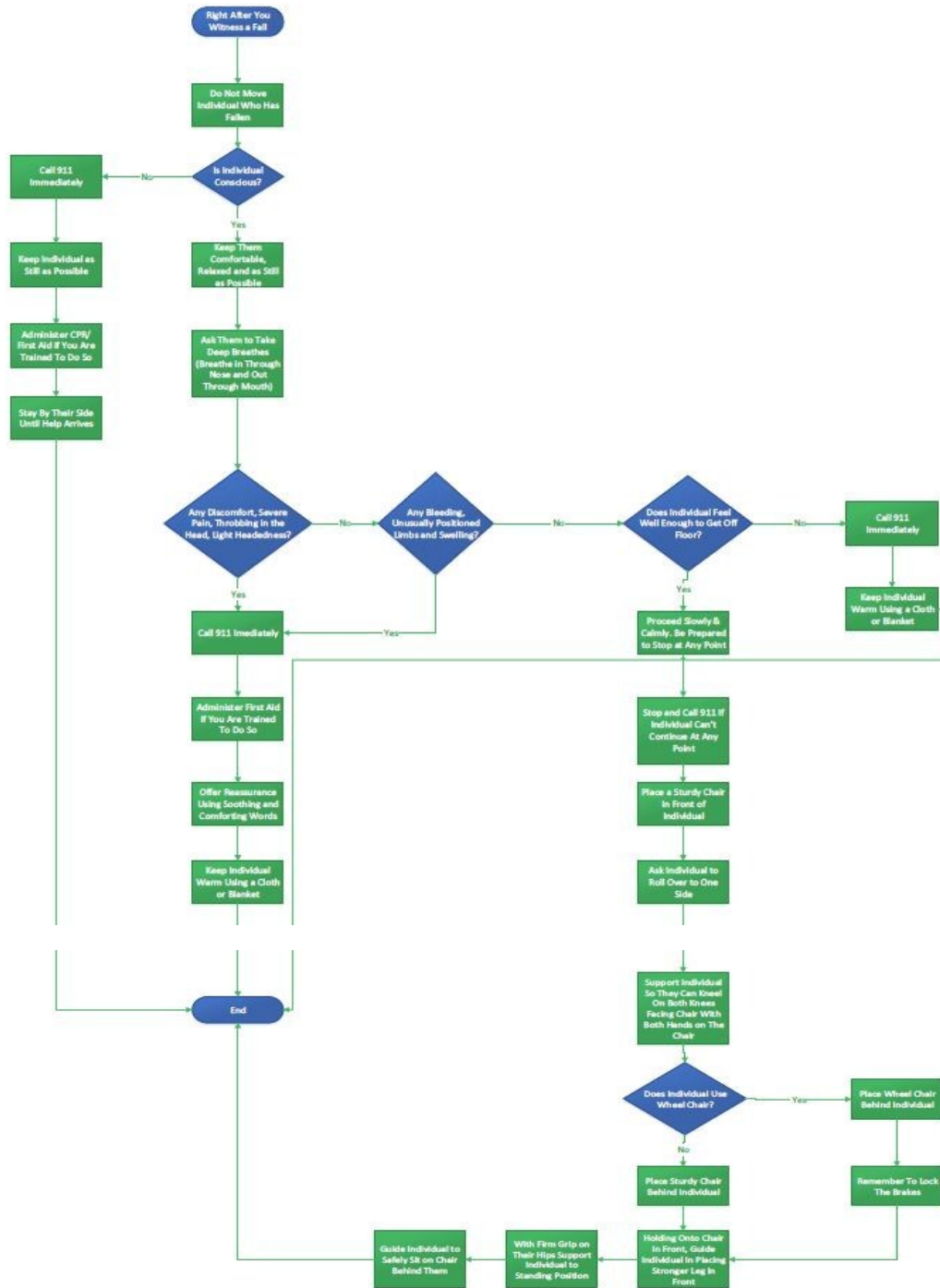
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## Appendix A: Flow Diagram (When you fall and you are alone)



## Appendix B: Flow Diagram: (When you witness a fall)



## Appendix C: What to do when you fall [Safe Life Senior, 2015]

- Prepare

Don't get up too quickly and if you are hurt, call for help



Look for a sturdy chair or staircase



Roll over to your side





- Rise

Slowly push your upper body up



Slowly get up on your hands and knees and crawl to the sturdy chair or staircase



Place your hands on the chair and slide one foot forward



- Sit

Keep the other leg bent with the knee on the floor



Slowly rise and sit in the chair



Sit for a few minutes before doing anything else



**Appendix D: Pictures - What to do when you witness a fall [Affinity Life Centre]**





## Appendix E: What to do when you can't get up after a fall [PHAC, 2015]

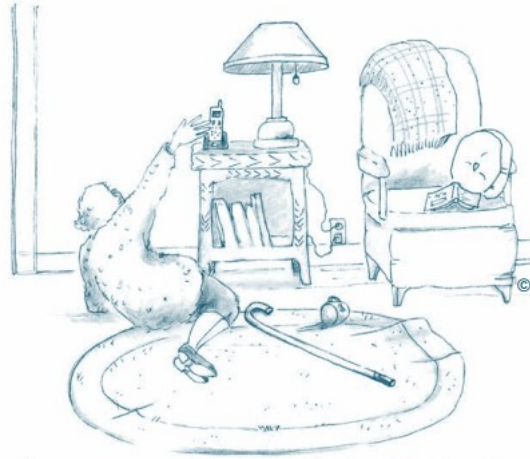
**1** Call out for help if you think you can be heard.

**2** If you have an emergency call device or telephone at hand, use it.

**3** If you don't, try to slide yourself towards a telephone or a place where you will be heard.

**4** Make noise with your cane or another object to attract attention.

**5** Wait for help in the most comfortable position for you.



## Appendix F: What to do when you witness a fall- details [PHAC, 2015]

**If the individual cannot get up,** call for help and administer first aid if you are able to do so. Help the person find a comfortable position and keep him or her warm using an item of clothing or a blanket.

**If the individual appears able to get up,** proceed with care and follow the steps below:

- 1** Bring a chair close by; help the person turn onto one side and bend the upper leg; help the person into a semi-seated position.



- 2** Placing yourself behind the person and getting a firm grip on the hips, help the person to a kneeling position with both hands on the chair.

- 3** Holding on to the chair, the person should then place the stronger leg in front. You may help by guiding the person's leg.

- 4** With a firm grip on the hips, help the person to stand, then turn and sit on the chair.



## **Appendix G: Post-Study Structured Interview Questions (Elderly Participants)**

### **These questions require yes/no answers**

Before today:

1. Did you know that some drugs could increase your risk of falling?
2. Do you have a fall prevention guide?
3. Did you know how to safely get off the floor after a fall?
4. Did you know the steps to take when you can't get up after a fall?
5. Did you know you could ask your doctor to check some specific things after you fall?

### **Questions for Qualitative Data Capture**

1. Tell me what it was like to use the app
2. What things did you like about it?
3. What things did you not like about it?
4. Do you have any idea of some drugs that could increase your risk of falling?
5. Tell me what to do when you can't get up after a fall
6. Tell me how you will safely get off the floor if a fall occurs?
7. Do you know what to ask your doctor to check after you've had a fall?
8. If you have this falls management app on your phone, what will it feel like?
9. What suggestions do you have to improve the app?

## **Appendix H: Post-Study Structured Interview Questions (Unpaid Caregivers)**

### **These questions require yes/no answers**

Before today:

1. Did you know that some drugs could increase your loved one's risk of falling?
2. Does your loved one have a fall prevention guide?
3. Did you know how to help your loved one safely get off the floor after a fall?
4. Did you know the steps to take when your loved one is injured after a fall?
5. Did you know you could ask your doctor to check some specific things concerning your loved one's health after they fall?

### **Questions for Qualitative Data Capture**

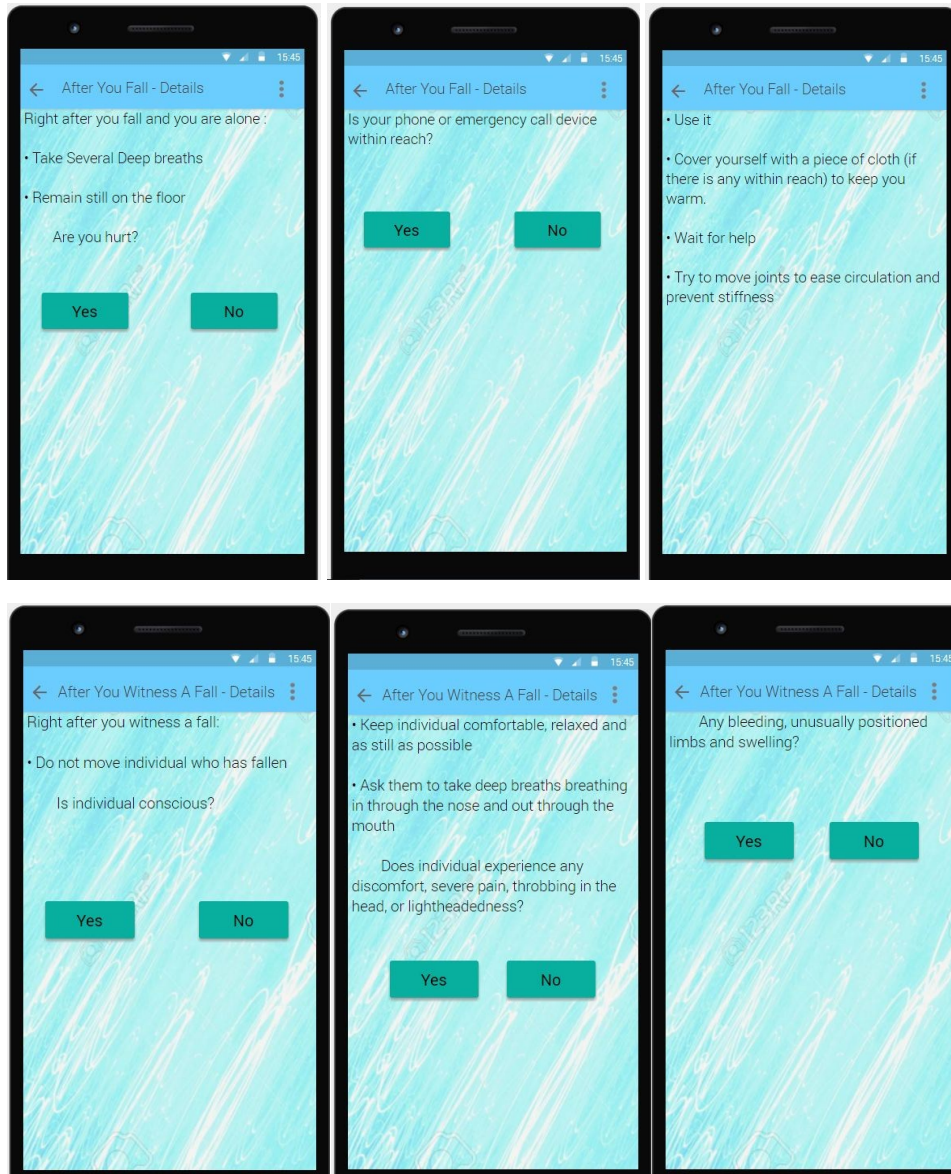
1. Tell me what it was like to use the app
2. What things did you like about it?
3. What things did you not like about it?
4. Do you have any idea of some drugs that could increase your risk of falling?
5. Tell me what to do when you can't get up after a fall
6. Tell me how you will safely get off the floor if a fall occurs?
7. Do you know what to ask your doctor to check after you've had a fall?
8. If you have this falls management app on your phone, what will it feel like?
9. What suggestions do you have to improve the app?

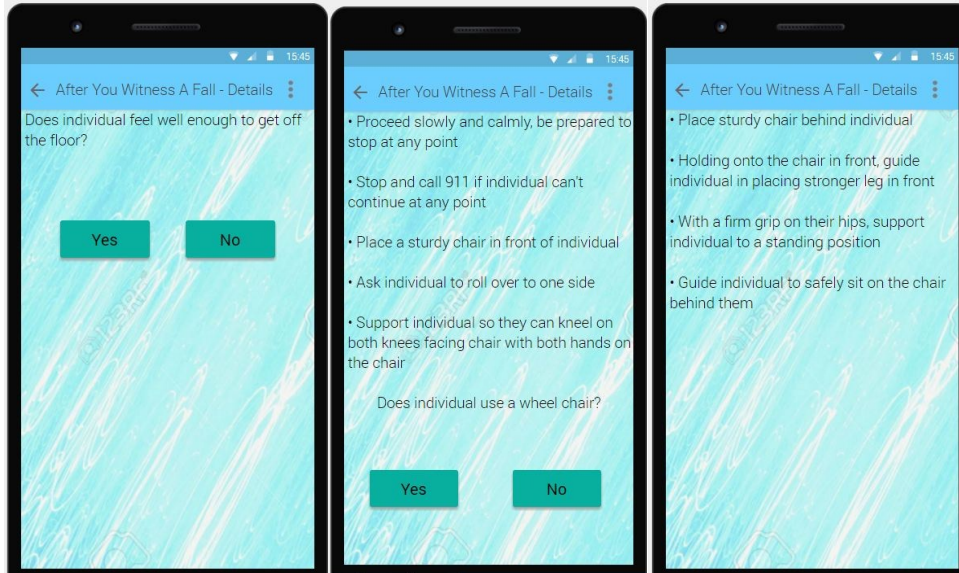


### Appendix I: Execution of all Tasks for all 9 Participants

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
<i>Not completed</i>	-	-	-	-	-	-
<i>Completed</i>	8	9	9	9	9	9
<i>Completed with help</i>	1	-	-	-	-	-
<i>Completed with Failures</i>	-	-	-	-	-	-

## APPENDIX J: SNAPSHOTS OF INERACTIVE SCREEN





## APPENDIX K: EVALUATION STUDY CONSENT FORM

We invite you to take part in a research study that is being conducted by me, Eseohen Imouokhome, a student at Dalhousie University as part of my master's degree program. The study is titled "Design and Evaluation of a Mobile Health Application for Falls Management in the Elderly."

This study will explore the usage of a mobile application for the elderly and their unpaid caregivers, how easy the app is to use, how intuitive the app buttons are when performing tasks with it and how useful the content of the app is to the elderly and their unpaid caregivers. The study will proceed in the following order:

Step 1: We will give you simple tasks to perform using the app and observe the processes you follow to achieve the given tasks. These tasks will also enable you to read through the contents of the app. Some examples of tasks you will be asked to perform include: Using the app, search for and tell us some fall prevention tips, Using the app, search for and tell us some risk factors for falls, Using the app search for and tell us some drugs that may increase fall risks, Using the app search for and tell us what you will do if you can't get up after a fall. While you perform your tasks, the processes you follow in performing your tasks will be observed by Eseohen and she will write down her observations.

Step 2: After you complete all your tasks, we will have a discussion session where we will ask you a couple of questions (9 questions) and discuss your thoughts. We hope that the feedback we get from you will be used to improve the app's functionalities to make usage easier and provide useful fall management information.

The members of our research team are:

**Lead Researcher :**

Eseohen Imouokhome, Master of Health Informatics Student  
Health Informatics, Dalhousie University  
Phone: 782-234-0263  
Email: es830257@dal.ca

**Supervisor:**

Dr. Samina Abidi, Assistant Professor, Medical Informatics  
Department of Community Health and Epidemiology  
Faculty of Medicine, Dalhousie University  
Phone: 902-494-1764  
Email: abidi@cs.dal.ca

**Co-Supervisor:**

Dr. Lori Weeks, Associate Professor  
School of Nursing, Dalhousie University  
Phone: 902-494-7114  
Email: lori.weeks@dal.ca

We are organizing individual meeting sessions in English in Halifax and we expect that about 12 people in total will participate in this study. Eseoehen will be present at all the meeting sessions. If you are interested in volunteering to participate in this research project, we invite you to stay. We would like to have input from older adults, including men and women, and caregivers who provide care to their family or loved ones. Each meeting session should last between 45 minutes to an hour.

Choosing whether to take part in this research is completely voluntary, and you are under no obligation to participate. If you do agree to participate, you can choose to skip any question asked in the discussion. There will be no negative consequence to you if you choose not to participate in this study or not answer any question. You can also choose to withdraw from participating at any point during this research or to take a break from the study at any point if you feel fatigued or bored.

The individual meeting sessions will be audio-taped and typed out. All the information collected will be kept confidential. The information will be kept on each team member's password protected computer in a password protected file. Only members of the research team will have access to the collected data. The typed data, presentations or reports will not contain any information that will identify you. No one outside the research team will be able to see or hear any information that will help them identify who has participated in this study. Data collected from this study will be destroyed 5 years after the study is completed.

It is important to note that there might be no direct benefits to you from participating in this study, as you may already be familiar with most of the fall management information the app contains however, your feedback will help us modify the app appropriately to make it as user friendly as possible and provide necessary fall management information.

Your signature below confirms that you have understood the information provided about this study and that you agree to take part in the focus group.

- I have received information about this study, and I have had the opportunity to have any questions about my participation answered.
- I agree that things I say or write can be used in reports of this research, but people will not know that I said these things.
- I agree that the meeting session will be audio-taped.
- I understand that if I have any concerns about the ethical conduct of this study, I can contact the following the Dalhousie University Research Ethics Board at 902-494-1462, or e-mail: [ethics@dal.ca](mailto:ethics@dal.ca).
- I have the freedom to withdraw from this study at any time and/or not answer any question.
- I understand that I can keep a copy of this signed and dated form.
- I understand that if I wish to obtain a summary of the results of this study, I will include my contact information below.

- I understand that the information will be kept confidential within the limits of the law.

Participant's Signature \_\_\_\_\_

Date \_\_\_\_\_

Researcher's Signature \_\_\_\_\_

Date \_\_\_\_\_

**Participant Request of Summary of the Results of the study**

- Yes, I wish to receive a summary on the research findings.

Email Address or mailing address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# Make Our app Better

**I will like to discuss an individual meeting session I am conducting as part of my master's degree at Dalhousie University in which you could take part in.**

**I have designed an app for the elderly and caregivers of the elderly to help manage falls among the elderly. To test how easy my app is to use and how useful the content of my app is, I am conducting an individual meeting session where the elderly and caregivers can use the app and give feedback on the app.**

**Before the study begins, I will give you a consent form which you will read and sign to show that you agree to participate in the study. I will walk you through tasks to perform with the app and at the end of these tasks, I will ask you a series of questions to get feedback on your usage of the app. I will also be taking audio recordings of your feedback and this meeting session will last between 45 mins to 1 hour.**

**Light refreshments will be provided.**

**If you are interested in volunteering to participate, have any questions or would like more information, please contact Eseoeh, a student at Dalhousie University by e-mail at [es830257@dal.ca](mailto:es830257@dal.ca) or by phone at 782-234-0263**

**APPENDIX M: EVALUATION STUDY ETHICS APPROVAL LETTER**

**Health Sciences Research Ethics Board**

**Letter of Approval**

**May 31, 2017**

**Eseohen Imouokhome**

**Computer Science\Health Informatics**

**Dear Eseohen,**

**REB #: 2017-4159**

**Project Title: Design and Evaluation of a Mobile Health Application for Falls Management in the Elderly**

**Effective Date: May 31, 2017**

**Expiry Date: May 31, 2018**

**The Health Sciences Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.**

**Sincerely,**

**Dr. Tannis Jurgens, Chair**

**Post REB Approval: On-going Responsibilities of Researchers**



**After receiving ethical approval for the conduct of research involving humans, there are several ongoing responsibilities that researchers must meet to remain in compliance with University and Tri-Council policies.**

### **1. Additional Research Ethics approval**

**Prior to conducting any research, researchers must ensure that all required research ethics approvals are secured (in addition to this one). This includes, but is not limited to, securing appropriate research ethics approvals from: other institutions with whom the PI is affiliated; the research institutions of research team members; the institution at which participants may be recruited or from which data may be collected; organizations or groups (e.g. school boards, Aboriginal communities, correctional services, long-term care facilities, service agencies and community groups) and from any other responsible review body or bodies at the research site.**

### **2. Reporting adverse events**

**Any significant adverse events experienced by research participants must be reported in writing to Research Ethics within 24 hours of their occurrence. Examples of what might be considered “significant” include: an emotional breakdown of a participant during an interview, a negative physical reaction by a participant (e.g. fainting, nausea, unexpected pain, allergic reaction), report by a participant of some sort of negative repercussion from their participation (e.g. reaction of spouse or employer) or complaint by a participant with respect to their participation. The above list is indicative but not all-inclusive. The written report must include details of the adverse event and actions taken by the researcher in response to the incident.**

### **3. Seeking approval for protocol / consent form changes**

**Prior to implementing any changes to your research plan, whether to the study design, methods, consent form or study instruments, researchers must submit a description of proposed changes to the REB for review and approval. This is done by completing an Amendment Request (available on the Research Ethics website). Please note that no reviews are conducted in August.**

### **4. Submitting annual reports**

**Ethics approvals are valid for up to 12 months. Prior to the end of the project’s approval deadline, the researcher must complete an Annual Report (available on the website) and return it to Research Ethics for review and approval before the approval end date in order to prevent a lapse of ethics approval for the research. Researchers should note that no research involving humans may be conducted in**

**the absence of a valid ethical approval and that allowing REB approval to lapse is a violation of University policy, inconsistent with the TCPS (article 6.14) and may result in suspension of research and research funding, as required by the funding agency.**

#### **5. Submitting final reports**

**When the researcher is confident that no further data collection or participant contact will be required, a Final Report (available on the website) must be submitted to Research Ethics. After review and approval of the Final Report, the Research Ethics file will be closed.**

#### **6. Retaining records in a secure manner**

**Researchers must ensure that both during and after the research project, data is securely retained and/or disposed of in such a manner as to comply with confidentiality provisions specified in the protocol and consent forms. This may involve destruction of the data, or continued arrangements for secure storage. Casual storage of old data is not acceptable.**

**It is the Principal Investigator's responsibility to keep a copy of the REB approval letters. This can be important to demonstrate that research was undertaken with Board approval, which can be a requirement to publish (and is required by the Faculty of Graduate Studies if you are using this research for your thesis).**

**Please note that the University will securely store your REB project file for 5 years after the study closure date at which point the file records may be permanently destroyed.**

#### **7. Current contact information and university affiliation**

**The Principal Investigator must inform the Research Ethics office of any changes to contact information for the PI (and supervisor, if appropriate), especially the electronic mail address, for the duration of the REB approval. The PI must inform Research Ethics if there is a termination or interruption of his or her affiliation with Dalhousie University.**

#### **8. Legal Counsel**

**The Principal Investigator agrees to comply with all legislative and regulatory requirements that apply to the project. The Principal Investigator agrees to notify the University Legal Counsel office in the event that he or she receives a notice of non-compliance, complaint or other proceeding relating to such requirements.**

#### **9. Supervision of students**

**Faculty must ensure that students conducting research under their supervision are aware of their responsibilities as described above, and have adequate support to conduct their research in a safe and ethical manner.**