ACCEPTANCE OF AMBIENT ASSISTED LIVING (AAL) TECHNOLOGIES AMONG OLDER AUSTRALIANS: A REVIEW OF BARRIERS IN USER EXPERIENCE

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ABSTRACT

One of the great challenges facing Australian society is that of an ageing population. Amongst the issues involved in this drastic demographic change, the most significant aspect is the demand for older Australians to live independently at home. The development of Ambient Assisted Living (AAL) technologies aims to address this issue. The advancement of AAL applications have been done to support the users with their daily-life activities and health concerns by providing increased mobility, security, safety in emergencies, health-monitoring, improved lifestyle, and fall-detection through the use of sensors. However, the optimum uptake of these technologies among the end-users (the elderly Australians) still remains a big concern. Thus, there is an elevated need to understand the needs and preferences of the seniors in order to improve the acceptance of AAL applications.

The aim of this study is to investigate the barriers and perceptions in the use of AAL applications amongst older Australians. Focus groups and quantitative surveys have been conducted to provide a detailed analysis of these impediments. The results show that there are different factors that restrict the use of these technologies along with the fact that elderly people have certain preferences when using them. An understanding of these factors has been gained and suggestions have been made to increase the acceptance of AAL devices. This work gives useful insights towards the design of AAL solutions according to user needs.

DEDICATION

I dedicate this work to my father, family and friends.

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I would foremost like to acknowledge the support of my principal supervisor Dr. Upul Gunawardana, who has showed unflagging interest in the project and encouraged me at all stages to perform my best work. I appreciate his expertise advise in the field, valuable feedback, and the time he has contributed to the supervision of my Master of Research. I also appreciate the useful feedback on early drafts of the thesis provided by Dr. Ranjith Liyanapathirana. I recognize Dr. Gaetano Gargiulo for his guidance and showing his interest in the project. Special thanks go to my teachers, Dr. Jack Tsonis and Dr. Alex Norman for their attention to detail and for providing direction in research training. I thank Bronwyn Sen for her administrative support. I would like to thank Abhishek Nair, one of the colleagues at School of Computing, Engineering and Mathematics (SCEM), Western Sydney University for his insightful feedback and support in conducting the focus groups. Also, I would like to thank all the participants of this study for their valuable time and enthusiasm for the project. A huge support was provided by the staff at Anglican Retirement Villages (ARV) in organizing the focus groups, for which I am grateful. I am also thankful to Miss Linda Thornley, who acquainted me with some useful resources in the library. I am obliged to the staff at the Student Support Services at the University for their support and motivation, which played a significant role in the completion of this thesis. I would also like to express my gratitude to my family for their incredible encouragement for the project and understanding my circumstances. And finally, I thank my friend, Mike Villa, for his continual encouragement of my work.

STATEMENT OF AUTHENTICATION

I certify that the work in this thesis is to my best knowledge and belief my own except as acknowledged in this thesis. I hereby confirm that the thesis has not been submitted anywhere else, either in whole or in part, for any degree at any institution.

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1. INTRODUCTION

Automated technologies have contributed to the development of healthcare all over the world. Ambient assisted living (AAL) technologies are mainly built to help older people and disabled people to live independently. In the past decade, the development of AAL technologies has been done particularly to answer the increased demand for aged care arising from the present demographic changes. AAL is based on the notion of ambient intelligence which refers to "electronic environments that are sensitive and responsive to the presence of people through the provision of an intelligent social user interface" (Broek et al. 2010). A number of AAL technologies are developed to provide ubiquitous care including fall-detection sensors, emergency alarms, mobile robots, smart homes and wearable sensors. AAL technology is designed to meet the older adults' wish to age, while being independent, as well as to ease the economic burden of healthcare (Steele et al. 2009). However, the adoption of these AAL technologies are still jeopardized by factors such as the lack of perceived usefulness, low user friendliness, and cost (Cleland, Guerrero & Bravo 2015). Thus, more focus must be laid on the user-acceptance domain of the AAL applications (Jaschinski & Allouch 2015).

The implications of improving the acceptance and employment of AAL technologies are widespread. The needs for aged care services are increasing exponentially along with the ageing population all over the world. The cost of aged care in Australia is estimated to increase from 8.4% of GDP to 14.5% of GDP by 2030 (Australian Institute of Health and Welfare 2012). AAL technologies are considered to become reality in terms of aiding aged care services for the elderly and thus, decreasing the economic and social effects of the ageing population on the government. According to a study in the UK, it was found that the replacement of medical visits by virtual visits lead to savings of around £ 1m (Alsulami & Atkins 2016; Burdea 2002). Similarly, the cost of a virtual visit in the U.S. is $30 as compared to $74 for medical visits (Chan et al. 2008). The increase in number of the elderly population does not only affect the government, the hospitals and

aged care professionals but rather, it has broader implications throughout the community.

The responsibility of care makes it harder for the family members and relatives of elderly people as they attempt to maintain a balance between their jobs and personal lives. AAL devices have proved to be very helpful in supporting disabled people (Fernández-Llatas et al. 2011). Following the benefits of the AAL technologies, the alarming change in the demographics of Australia makes it a necessity to work towards their development and more widespread acceptance of their use.

Although the development of AAL applications, specifically in the ICT area, is significant and gratifying field of work; it can also be a disconcerting issue: gratifying because AAL solutions provide the independence to the users, disconcerting because it is often easy to develop these technologies but difficult to meet the various users' needs with the single technology. The end-users (elderly people) of the AAL solutions are still unable to use these technologies because of internal and external barriers. The internal barriers refer to those faced by older people irrespective of the technical characteristics. These include their concerns and preferences in addition to the main factors. The external barriers refer to those that restrict the adoption due to the nature and limitations of the considered technology. It is found that engaging the users during the design phase of the technology lead to improvement in their adoption (Abril-Jiménez 2009; Pino et al. 2014; Davidson & Jensen 2013a). There has been enormous research done towards the development and improvement of AAL technologies all over the world (Sixsmith et al. 2014; Vaziri et al. 2016; Broek et al. 2010; Stav et al. 2013; Klein, Schmidt & Lauer 2007). However, the issue that hinders the successful deployment of these technologies is the user interface. Even though few projects have been done on user acceptance of AAL devices in different parts of the world, there are only a scarce amount of similar studies that have been done within Australia (Bradford et al. 2017).

This project aims to study the barriers in user acceptance of AAL technology among older Australians. The objective of the study is threefold: a) to gain knowledge of barriers to the acceptance of AAL technologies among older adults;

b) to understand the needs, preferences and concerns of older people while using AAL technologies; c) to seek possible solutions to overcome some of these barriers through interrogation and exploration of suggestions made by the seniors. The barriers to adoption have been understood in depth by conducting focus groups and questionnaires. In doing so, the participants were introduced to the various dimensions of AAL including the current demography of Australia, the definition, functions and users by using examples of existing AAL devices and concepts. To deliver the information, a video, as well as PowerPoint presentations, were used, as described in chapter four in greater detail. The results elicited, from the literature review done on types of existing AAL technologies, were useful in conducting the focus group, and introducing AAL devices to the participants. The questionnaire was also developed based on the knowledge gained from the substantial findings in the field. The quantitative analysis of the acquired data has demonstrated some understanding of the concerns of the elderly associated with the use of the AAL technologies. The overall results have revealed suggestions for improving the acceptance of the AAL applications among the primary users (the elderly).

It is relevant to mention that the study doesn't aim to understand the behaviour and attitudes of the users from a psychological point of view. It is rather focused on understanding the barriers for users face from a technological perspective. The research will demonstrate the need for addressing these barriers by using the results from the study. It will also advocate the claims for changing the government's policy for care of the elderly, due to its important social implications.

1.1 Research Objectives

1.1.1 Motivation

Recent developments in medicine and technology have helped the population lead a healthier and longer life in comparison to previous times. In fact, the population of older people (above 65) among the world population is expected to double by 2050 (Nations 2015). The demographics of Australia show that the percentage of the elderly is the highest increase among the country's total

population (Statistics 2016). According to the Australian Bureau of Statistics, the number of people above 65 in Australia is anticipated to increase by 84.8 percent from 3.1 million to 5.7 million between 2011 and 2031 (Statistics 2015). These demographic changes will lead to economic and social impacts, including a reduction in the per capita output (Studies 2011) and rising demands for aged-care aids. Thus, new challenges will arise for the government. The ageing population will be a big concern for the health care system and will bring new challenges for society. There will be an growth in diseases related to ageing, such as Alzheimer's, with no cure (Australian Institute of Health and Welfare 2012). It is estimated that there will be a rapid surge in health care costs in Australia in coming years (Coory 2004). The undersupply of caregivers for the elderly impacts the physical and mental health of the informal caregivers like family and friends (Kenny, King & Hall 2014). The demographic trends leads to difficulties such as increased health issues, seniors' mobility and independence, care and utilization of social care services (Klima, Jainszewska & Mordwa 2014). These challenges necessitate the need for new reliable, self-sustainable, technological tools. AAL technology is seen as an evolving innovation that holds the potential to support the changing needs of the elderly.

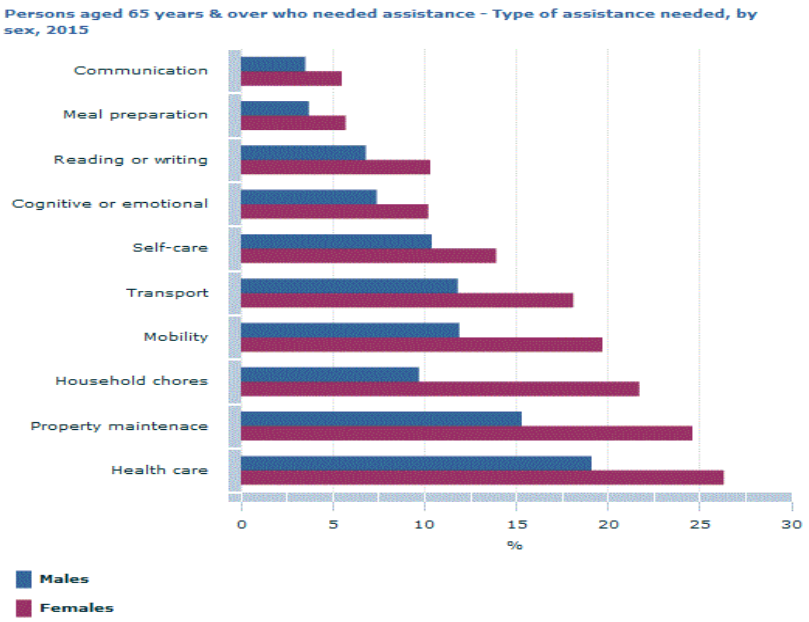

FIGURE 1: ABS SURVEY OF DISABILITY, AGEING AND CARERS: SUMMARY OF FINDINGS-2015

There are different types of AAL technologies currently available, and some of them are still in the developmental phase. While these technologies are more widely adopted in some selective countries, there are still ongoing struggles in other areas to deploy them. Even though the ambient assisted living technologies are built to help older people, their optimum use is still deficient. Thus, it is important to improve the uptake of these technologies to be able to cater for the needs arising from the change in demography. One of the motivations to conduct this study is towards empowerment of the elderly through the technological support.

1.1.2 Research Questions

The main research questions explored in the thesis are as follows:

Research question 1: What kind of AAL technologies do older people currently use, how do they use it, and for what purpose? If they don't use any kind of AAL technology, what are the reasons?

Research question 2: What are the barriers faced by the elderly in the uptake of AAL technologies?

Research question 3: What are the concerns and preferences of older adults associated with the use of AAL devices?

Research question 4: What additional feedback and suggestions about improving the AAL applications (e.g. design implications and role of government support) can be gathered?

These research questions were explored through a mixed-methods approach through focus groups and by administering written questionnaires among the end users of the AAL technology. Table 1.1 summarises the methods used for answering the above research questions.

Table 1.1: Research aims of the project

Phase	**Research Question**	**Methods**
Introduction of AAL technologies to end users (participants) followed by Open-ended Discussions	**What kind of AAL technologies do the older people use currently: how do they use it and for what purpose? If they don't use any kind of AAL technologies, what are the reasons?**	**Oral Presentation and Videos on AAL technologies followed by open discussion**
Design: Focus Group Discussion Based on five themes (derived from the literature review)	**What are the barriers faced by the older Australians in the uptake of AAL technologies?**	**Focus Group discussion based on five themes**
Experimental Research: Field Study	**What are the concerns and preferences of older adults associated with the use of AAL devices?**	**Written Questionnaire**
Experimental Research: Field Study	**Additional feedback and suggestions about the AAL applications. design implications and the role of government support.**	**Open-ended discussion following the focus group**

1.1.3 Contributions

The thesis makes conceptual as well as a practical contribution towards improving the overall design and user interface of AAL technologies. The conceptual contribution forges ahead the barriers hindering the adoption of AAL technologies by older Australians. It illustrates the role of involving older adults in the design phase of these technologies. It also brings forward the assumptions made by the designers and developers of AAL applications about the end users of the technology. It is important to understand the different stakeholders to design user-centred technology (Nedopil, Schauber & Glende 2013b). Practical contribution of this thesis is made through demonstration of the guidelines for the design of these technologies based on concerns and preferences expressed by the end users. These guidelines may be utilised by the designers to implement technical solutions during their deployment. The results from the study also reflect some noteworthy ideas that could be utilised by the social workers (carers) and the government to improve aged care as well as improve the financial implications resulting from the demographic change. These results have also been published in the IEEE Explore, as part of Life Sciences Conference proceedings (LSC), 2017 (Maan & Gunawardana 2017).

1.2 Thesis Organisation

The thesis is divided into five chapters. Firstly, the second chapter expounds the literature gap through reviewing the background of AAL technologies including 1) the history of AAL technologies, 2) types of monitoring technologies, 3) design guidelines for AAL components 4) users of AAL technologies and 5) user interface of AAL technologies. Secondly, the third chapters describe the main barriers to adoption of AAL technologies among the older people as demonstrated by previous studies. Thirdly, chapter four discusses the methodology of the study in detail including the Human Ethics consideration while undertaking the study. Fourthly, chapter four explains the results obtained from the mixed methods approach. Finally, the last chapter (5) elucidates the general discussion and conclusion with respect to the challenges faced towards the adoption of AAL technologies, and suggestions to draw implications useful for the designers and future researchers in the field.

2. LITERATURE REVIEW

A thorough background of the AAL technologies has been given in this chapter, and organised as follows: Section 1 presents the definition of AAL technologies and an insight into different applications and techniques used in their context. Section 2 discusses the history and evolution of AAL technologies, including some turning points during their advancement. Section 3 describes the AAL elements in detail and discusses their design recommendations from the previous studies in the field. Section 4 provides the description of different user categories. Finally, the discussion concludes by highlighting the current gap in the field. Figure 2 gives an overview of AAL features along with its end-users.

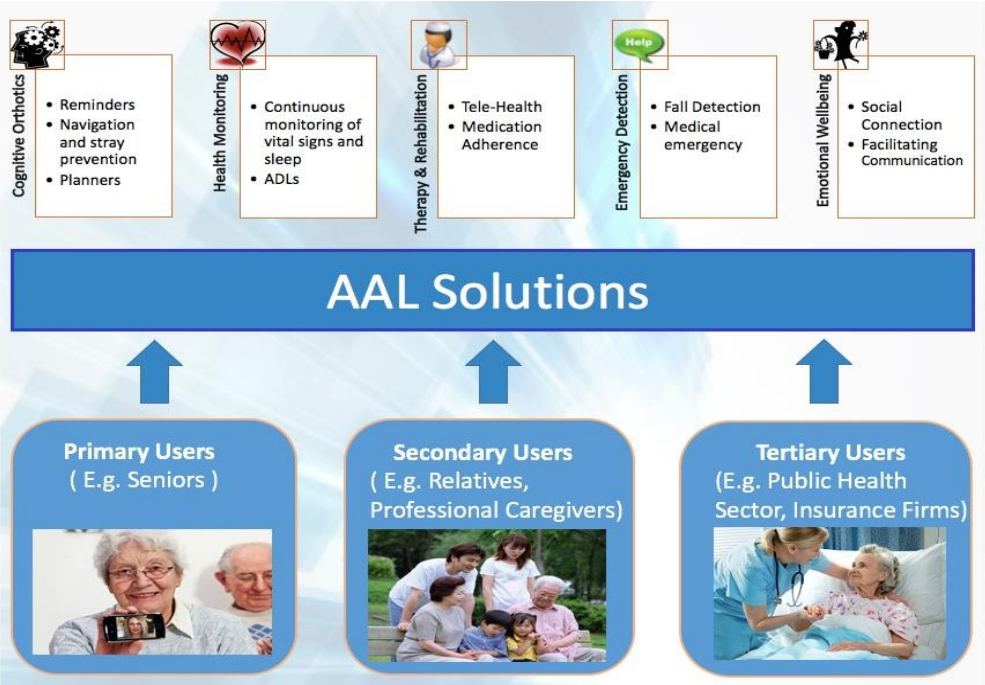

FIGURE 2 : AAL FEATURES AND TYPES OF USERS

2.1 Definition of AAL Technologies

Assisted living provides the electronic environments that attend and respond to the presence of the people (de Ruyter & Pelgrim 2007). AAL includes the intelligent systems designed to monitor, assist and promote the healthy environment to enhance independent living for elderly people (Davidson & Jensen 2013b; Trevisan 2016). Using ambient intelligent notion, AAL tools are employed with a common objective to empower the elderly and disabled with special needs, help them live independently in domestic environment (Botia, Villa

& Palma 2012), assist them with routine activities, and provide health monitoring and treatments at home to reduce the cost of nursing home care (Queirós et al. 2015; Steinke, Ingenhoff & Fritsch 2014; Karunanithi et al. 2010).

Recent research and development are working towards advancement of these technologies. Within the past decade, AAL technologies have been an important research area with an aim to improve the assistance available to elderly people and to provide ubiquitous care at home. They have been able to support the seniors with increasing their mobility (Trevisan 2016), helping with security, obtaining treatments remotely and becoming more active socially (Anglian et al. 2016; Steinke, Ingenhoff & Fritsch 2014). Smart home technology, as a representative of AAL, is the most established form in the market with a wide range of consumers (Reddy et al. 2016). Formulation of smart homes (SH) has always been focused on consideration of privacy while providing assistance to improve the elderly's quality of life. In recent years, smart home applications have been developed for saving energy, increasing safety, tracking falls, sensing smoke and fire and space illuminating management by integrating various tools such as actuators, sensors, internet and alarms to monitor and collect data (Amiribesheli, Benmansour & Bouchachia 2015). SH incorporates multiple information and communication technology (ICT) solutions and protocols like ZigBee, Bluetooth, and programmable logic controller (PLC). Contemporary research has found wearable sensors as the most popular kind of AAL technology within healthcare (Gao et al. 2016). Wearable devices are the electronic sensors that can be worn and are capable of continuously monitoring the internal health of a person without restricting the motion. Existing wearable electronics are able to monitor only the physical activities of an individual. However, research has been undertaken to develop sensors that can monitor user's health at molecular levels. Presently, intensive research is being conducted to develop mobile robots, within the context of smart home environments (Brady, Sterritt & Wilkie 2015). It is because of the need for integrating artificial intelligence (AI) within the AAL sphere. The elderly's need to be able to monitor things remotely and get help in physical activities has led to work on developing mobile robots. This will help in increasing the elderly's mobilisation and access to transport (Doll & Balaban 2013). Most assistive robots help the older adults with the daily life activities like

fetching objects, grooming, cleaning house (Broekens, Heerink & Rosendal 2009; Xu, Deyle & Kemp 2009). Some of the robots also assist in enhanced activities such as social interaction, hobbies and acquiring new knowledge (Smarr, Fausset & Rogers 2010; Rashidi & Mihailidis 2013).

Different techniques are used to support the AAL devices including some algorithms. Some of the most common computational techniques used are location tracking, activity recognition, context modelling, deviation or irregularity of behaviour detection. Human activity recognition (HAR) is the most frequently used constituent in the context of AAL tools. It detects human activity from the low-level sensor data (Rashidi, Diane J. Cook, et al. 2011). This data varies being derived from different types of sensors. The data being generated from sensors used in wearable devices such as accelerometer and gyroscope forms time series pattern. Numerical or categorical data is being derived from the motion sensors and other ambient sensors such as thermographic devices (Rashidi & Mihailidis 2013). Cameras record image and video data to distinguish different activities such as group activity, single body movements, action, and more.

For mobile activity recognition, time series data is recorded through sensors using Nyquist criterion. Algorithms such as Fourier transforms are used for on-chip processing (Keogh et al. 2004; Preece et al. 2009). Activity motif is also used apart from the traditional supervised models by some researchers to directly populate the data to recognise activity patterns (Tanaka, Iwamoto & Uehara 2005). However, to be able to recognize more compound activities, ambient sensors are used in a pattern to examine the residential activities (Wadley et al. 2008). The algorithms used by ambient sensors are dependent on the labelled data, such as neural networks (Ustinova, Ganin & Lempitsky 2017), a combination of models, and case-based reasoning (Zhang, McClean & Scotney 2012). Graphical methods such as Markov Chains (Chiappa 2014) and Dynamic Bayesian network (Figueiredo et al. 2014) are amongst the most popular ones for sequential data. In spite of widespread usage of supervised methods, they lack in their validation in the real world. The assumption made about the activities for supervised modelling turns out to be superficial when compared with the

activities in the real world. This is due to the fact that the residential activities of the individuals vary due to the differences in physical, cultural, social activities and varying lifestyles in different parts of the world (van Bilsen et al. 2006). To make the interpretation of activity data easier, data mining methods have been in existence for the past decade (Kwapisz, Weiss & Moore 2011). Some of the usual data mining methods for definition of activities include frequent sensor mining, simultaneous frequent-periodic activity pattern mining, mining discontinuous activity pattern, and web mining (Rashidi & Mihailidis 2013; Rashidi, Diane J Cook, et al. 2011; Rashidi & Cook 2010). For comprehensive information, Visual activity recognition is used, but privacy always remain an issue. Video-based activity recognition is complex in terms of the algorithms used and due to the nature of highly varying natural settings. The types of approaches used for visual-based activity recognition are the single layer and the hierarchical (Rashidi & Mihailidis 2013; Aggarwal & Ryoo 2011). Simple activities and human gestures are recognized by using single layer approach to a sequence of images, while more complex activities are recognized by using hierarchical approach.

AAL applications are required to embody various contextual details, like the layout of residential activities, sensor information, user persona and user needs. They also represent temporal information like medical records, and spatial statistics such as residential layout and its vicinity (Mihailidis & Fernie 2002; Rashidi & Mihailidis 2013). Context-aware applications represent information based on metadata statistics such as energy level, confidence and resolution using techniques like markup based models, situation modelling languages and key-value based models (Brdiczka, Crowley & Reignier 2007; Salber, Dey & Abowd 1999; Rashidi & Mihailidis 2013). Additionally, ontology-based models are developed to recreate contexts collectively in a hierarchical manner. Some researchers have combined the concepts with online interfaces such as EHow or WordNet to make the identification of concepts easier by combining new ones with the existing ones (Wyatt, Philipose & Choudhury 2005; Chen & Nugent 2009). Detection of finding an irregularity in the activity pattern through the data is mainly used for medical purposes, detecting dangerous situations and change in the walking pattern by the AAL tools. Most common methods used for anomaly detection are using rule-based principles, heuristic methods, temporal

correlation and similarity-based techniques (Perry et al. 2004). Location mapping is done by AAL systems using various RFID and PIR sensors. In addition to the WIFI systems such as RADAR (Longhi et al. 2014), systems such as active badge and ultrasonic are used for locating pathways (Want et al. 1992).

AAL applications are mainly categorised into the following areas: roaming pattern recognition, monitoring devices, emergency detection, and therapy applications. Development of pervasive healthcare applications has been done to assist the older people in monitoring their health as well as supporting them in living independently through emergency detection and location tracking (Varshney 2007). The ultimate goal of AAL tools is multifold, with the main emphasis on getting regular updates through health monitoring, decrease the liability of caregivers, automatic support and autonomous ageing in place. The pattern obtained from monitoring daily life activities are helpful for older adults who face deterioration in cognitive functioning. Rationalization of these patterns can be utilized for improving the treatment and to set reminders for actions that need to be carried out (Ni, García Hernando & de la Cruz 2015). Previous studies have shown the effectiveness of applications developed to help improve behaviour of dementia patients (Unützer 2004; Unützer et al. 2002). Different approaches are used by different applications for a variety of purposes. Some applications are aimed at carrying out health monitoring for specific health issues whereas some applications concentrate on daily routines and reminders.

A few applications monitor multiple tasks or activities while others focus on monitoring single task. Nambu et al. have used watching TV as a single action for health monitoring purpose (Nambu et al. 2005). Similarly, another project is based on using a smart cane to monitor walking patterns and alerts the elderly in case a fall is expected (Wu et al. 2008; Rashidi & Mihailidis 2013). The system proposed by Chernburoong et al. is based on monitoring multiple activities using multiple sensors attached to the body for daily life activities such as daily workout, reading, writing, washing, brushing, cleaning, cooking, eating food and more. (Chernbumroong, Cang & Yu 2014). Projects such as CASAS (Rashidi & Cook 2009) and IMMED (Mégret et al. 2010; Gaestel et al. 2011) uses a subset of daily life activities using sensors and cameras to identify the general performance

of the elderly. Monitoring of vital signs is a popular concept under the umbrella of AAL applications narrowed to the use of wearable sensors. Some of the commercial telehealth projects under this category are: AMON by ETH Zurich University (Scheffler & Hirt 2005; Lukowicz et al. 2002), EU funded project SOPRANO (Sixsmith et al. 2009), Philips's eTrAC (Lieberman & Spaulding 2017), LG's medical monitors (LG Electronics 2017), Intel-GE care cloud-based telehealth solution (Mclntyre Hooper & Fox 2017), HealthBuddy by Bosch (Vogan et al. 2012). However, healthcare professionals have a huge role to play in maximising the potential of the available telehealth devices (Olson & Thomas 2017).

Roaming pattern recognition is used for wandering prevention among the older adults suffering from dementia. Wandering is one of the most troublesome behaviours amongst dementia patients leading to falls, getting lost, emotional affliction and elopement (Lin et al. 2014). Wandering prevention tools have been mainly categorised into three types based on the technique used as follows: Event monitoring-based, Trajectory tracking-based and Location-based prevention of wandering-related adverse (Mangini & Wick 2017). Projects such as KopAL (Fudickar et al. 2011) and DIANA (Doughty et al. 1998) have been developed to record activities of the dementia patients to track their health and alert the caretakers if any irregular behaviour is noticed. GPS (global positioning system) technology is used by major commercial projects for wandering prevention tools (Robinson et al. 2006; Mihailidis & Fernie 2002; Ou et al. 2015; Shenvi et al. 2016). Yang et al. proposed a GPS device installed in prayer beads to record the trajectory of the elderly to detect early-stage dementia (Ou et al. 2015). Lin et al. have used RFID technology to monitor a senior to check if they have approached an unsafe area (Lin et al. 2006). Another project by Koldrack et al. have used geo-fencing, a virtual indoor fencing for possibly dangerous situations (Koldrack et al. 2013).

Machine learning algorithms have also been used to identify and classify types of activities for health monitoring purpose. Machine learning advanced initially from the investigation of computational learning hypothesis in artificial intelligence. Machine learning investigates the examination and development of

calculations that can make predictions and operate on data. These calculations are contrary to static programming as it operates on making information-driven forecasts or decisions, through building a model from test inputs (Mannila 1996). Fernández-Llatas et al. proposed a computer architecture (eMotiva) based on machine learning to predict the behaviour pattern of dementia patients in the framework of a nursing home based pilot study (Fernández-Llatas et al. 2011). The main aim of the study is to detect early signs of dementia and help health professionals to stop cognitive impairment among older adults. Rafferty et al. present an approach to help predict triggers for those suffering from Autism spectrum disorder (ASD) based on training system using supervised machine learning. The data derived from sensor network monitoring of ASD patients is used to train the prediction system. Support vector machines (SVM) is one of the popular data engineering methods used for applications such as face identification, text categorisation and stock classification (Amiribesheli, Benmansour & Bouchachia 2015). Deep learning tools are more recently used for data analysis, to develop behaviour mobility system, with an aim to recognise health changes at an early stage (Eisa & Moreira 2017; Meng, Miao & Leung 2017; Hassan et al. 2017). Several artificial intelligence techniques and Navigation assistance tools have been used for predicting the elderly's behaviour for early dementia detection (Cleland, Guerrero & Bravo 2015; Páez et al. 2015; Broek et al. 2010; Costa, Julián & Novais 2017; Patterson et al. 2004).

Cognitive artificial devices also referred to as Cognitive Orthotics have significant potential in helping the seniors with cognitive decline. It is a type of assistive technology that supports the elderly to cope up with the cognitive decline by helping them adapt to changes while performing routine activities satisfactorily. This allows elderly people to stay longer in their own homes. The notion of these tools have been in existence since 1960s but has been very eminent in the field of socially assistive robots since past decade (Feil-seifer & Matari 2005). In the past, cognitive orthotics were confined to alarm systems to remind them of prescribed tasks at a certain time. Auto-reminder is a system based on AI planning and plan management technology that is able to discern between the scheduled activities and users' current activity and resolves on whether and when the reminder should be issued (Pollack 2002). With the help of AI and data mining, these tools

are now being developed for rehabilitation purposes. Assistive technology for cognition (ATC) interposition attend to a range of issues resulting from cognitive impairments such as complex attention, executive reasoning, sequential processing or inhibition of specific behaviours (Lopresti & Mihailidis 2004). Literature reveals that ATC intervention abet therapists by increasing the efficiency of conventional rehabilitation methods by improving a person's ability to participate in therapeutic activities and by expanding the contextual spectrum for exercising those tasks (Hoey et al. 2010). Some of the cognitive artificial tools work by storing series of images and videos about certain events to act as a retrospective memory aid to help dementia patients recollect important experiences from the past (Hodges et al. 2006; Lindquist et al. 2000). Phillips Lifeline by Phillips is a medical alert service that uses automatic medication dispenser combined with medication reminders. It has been found useful for elderly people with dementia for medication management (Philips 2016). It helps the seniors to adhere to their prescribed medication and alerts the caregivers in events of anomaly detected in the medication routine.

Although much research has been undertaken towards the evolution of these technologies (Queirós et al. 2015), the demand for a common platform for sharing these technologies still remains a big concern (Memon et al. 2014; Vaziri et al. 2016). Future work needs to be done towards increasing interoperability and standardization of the developed AAL solutions in order to create more synergetic technologies. The inter-organizational collaboration can possibly lead to the formation of open systems which may, therefore, save costs for the technology needed for integration of available technologies (Memon et al. 2014). UniversAAL is one of the scarce projects, that has worked towards developing an open/shared cross-application platform, to encourage the development of more innovative feasible AAL solutions, both economically and technically (Gambi et al. 2017). One of the major concerns around the development and use of AAL devices is also the security standards, especially for the technologies used in healthcare (Ng, Sim & Tan 2006; Memon et al. 2014; Al-Shaqi, Mourshed & Rezgui 2016). Some cryptographic approaches, both based on design and services, have addressed critical issues like access control, emergency access, and sharing data. However, more methods need to be developed to deal with the underlying issues

to develop secure and private systems for electronic health services (Yüksel, Küpçü & Özkasap 2017).

2.2 History of AAL

Ambient assisted living solutions have been recognized as the feasible option to alleviate the economic impact posed by the demographic changes all over the world (Meersman et al. 2013). AAL is derived from the assisted living solutions based on the concept of "ambient intelligence". Ambient Intelligence (AmI) allude to the electronic environments that can detect and acknowledge the presence of people. The concept of AAL was mainly identified after the Active and Assisted Living Joint programme was started by European Commission in 2008 with approximately 50 funded projects over a budget of EUR 600 million (Meersman et al. 2013). It was primarily centred around the improvement of elderly's independence, prevention and maintenance of chronic conditions and increasing social intervention.

The initial introduction of AAL technologies started with the discovery of smart home technologies for home automation and aiding domesticity (Ricquebourg et al. 2006). The idea of ambient assisted living was launched back in 1998 by the company Phillips through a series of workshops aimed at investigating how the electronics industry could be utilized to develop user-friendly tools with a vision to assist the consumers in 2020 (Zilch, Epstein, Birrell & Dodsworth 1998). Following this, projects including the biggest frameworks like AALIANCE and SOPRANO-IP were started by the European Commission within the context of AAL (Klein, Schmidt & Lauer 2007; Broek et al. 2010). MIT and the Fraunhofer Society introduced the projects that began to focus on user-experience research. The advanced topics within AAL were addressed after the biggest symposium called The European Symposium on Ambient Intelligence (EUSAI), was held on Ambient Intelligence in 2004.

The AAL technology has evolved through three generations of various designs for different purposes. The first generation technology was more focused on personal response and community support systems (Doughty, Cameron & Garner 1996). For example, an alarm is worn by an elder person to alert the emergency response systems in case of fall or other crisis situations (Naumann et al. 2011).

This helps older adults in seeking help as the alert is received by 24-hour emergency centres which will respond to the alarm. But this technology has some loopholes as sometimes the incidences could occur at night in case users might need to use the bathroom and the fall could occur before they could even press the alarm (Doughty, Cameron & Garner 1996). However, the second-generation technologies addressed the failures of the first-generation system, especially the inadequacy of system for high-risk circumstances. These technologies used sensors and other electronic components to monitor and recognize any emergency without being dependent on the memory of the user. For example, older adults often to forget to switch off devices like stove, air-conditioners and more. The AAL technologies were then able to monitor and notify the authorities automatically. Nonetheless, the drawback of the second generation AAL technologies is that some people find it obtrusive. In spite of this, these technologies are very popular in AAL market and used by the older adults at home.

Although the first two generations have been able to increase the security of the elderly, they have not been able to solve the problems of managing poor memory, personal hygiene, and isolation among elderly people (Doughty, Cameron & Garner 1996). The third generation of AAL technologies are still under development and would make use of latest telecommunication services and personalised innovative tools to improve the quality of life of elderly people. For example, highly educated elderly people who might want to see the record of their medical history would be able to access it through enhanced computing features without allowing the misuse of their personal information (increased data privacy) (Yüksel, Küpçü & Özkasap 2017). The facility for online consulting with the doctor would be more common in the future and would require the employment of certain medical devices for measurement. The third generation will utilize the features of health monitoring from the second generation for developing the devices that could be used for medical diagnosis. These devices will be robust and the hardware interface design will intervene with the ease of use for the older adults. These technologies will also aim to increase the social interaction for elderly from their home. Video conferencing will be combined with touch sensors where an individual will be able to feel a virtual presence

(Singhal et al. 2017). This will allow the relative or family members to hold the hand of sick person virtually. Robotic scalps are currently under development to enable the remote surgery (Ladd et al. 2017; Song et al. 2015). However, ethics, information security and safety are still major concerns in the employment of these technologies at the initial stages of development. The main aim of developing these technologies is to improve the living style for elderly people in their domestic environment. Consequently, it will reduce the number of medical visits and the hospital admissions which will ultimately cut down the pressure of work on medical professionals and the cost of medical services. Thus, AAL has remarkable scope for improving the overall health status of elderly people and therefore can act as the substantial substitute for the residential care and nursing homes. However, careful planning will be required to increase employment of the AAL technology.

Literature reviewed indicates that the conceptualization of AAL has gone through a period of momentous changes over the years, the main adaptation being the transformed understanding of AAL as "ambient assisted living" – technological pitched outlook- moving to AAL as "active and assisted living"- end users driven outlook (Aumayr, Bleier & Sturm 2017). The central point of the AAL solutions in the past was primarily to detect emergencies, with focus on living spaces, fall detection, and more. The marketing of these products was rapid, safety being the prime motto, now being established for over 20 years. However, there was no leap forward between 2000 and 2010, except some more sophisticated looking products, with low reliability and false alarms. Later, after the introduction of the touchscreens, Exergames (combination of exercise and gaming), Precision motion control (Tan, Lee & Huang 2007), motion sensing input devices like Microsoft Kinect (Zhang 2012), the label ambient and assisted living transformed to active and assisted living (Aumayr 2016). Together with the use of wearable sensors, smart home, enhancing communication, empowering independence and more, AAL has become the term associated with technologies centred on supporting the individuals with special needs. With increasing demand for healthcare and low-cost solutions, AAL is seen as the prospective hope. ICT-based AAL has potential to provide affordable healthcare, improved therapy and aid

medical professionals by analyzing patient-health data (Sun et al. 2016; Peruzzini & Germani 2014; Algilani et al. 2016).

2.3 AAL Elements

More or less, advanced AAL technologies are mainly focused to provide support to the users through monitoring different parameters of the individuals including daily life activities (ADLs). Sensors (e.g. detecting falls or measuring heart rate), being the focal point of AAL, monitor the health of the user and alert the system, to take an action in case of risk or critical situation (e.g. prompting emergency call in case of fall detection). The main types of monitoring technologies under the umbrella of AAL that have been used in the past few years are discussed below, based on a literature review:

2.3.1 PIR Motion Sensors

PIR motion sensor technology uses the Infra-Red (IR) sensors to detect the presence of the occupants of the room using the temperature changes (Shin, Lee & Park 2011). The use of this technology has mostly been described either for the monitoring of major events like detecting falls or health status of the elderly, while a few articles defined its use to measure gait velocity and sleep patterns. These sensors can easily differentiate between activities like use of the stove, use of water, moving cabinets, due to their sensitivity. The data collected through these sensors are recorded to notify any change in the regular patterns of the daily life activities of the elderly (Wu & Xue 2008).

2.3.2 Wearable Sensors

Wearable sensors are able to collect health data directly as they are placed either on the limbs or clothes. (Gao et al. 2016). These sensors have very high accuracy which is really helpful in keeping a check on health. Most articles report the use of wearable sensors either to monitor the general health or to provide treatments at home by combining the technology with other medical devices (Stav et al.

2013). Some studies have also used these sensors to help differentiate between important events like falls, exercising, sleep and for sensing posture transitions.

2.3.4 Video Monitoring Sensors

Video monitoring technology is mostly used in combination with other technologies. The cameras are placed to notice any changes in the activities of the elderly using background subtraction (Shah et al. 2014). The aim of video monitoring technology is to detect the significant events like falls and to recognise the posture transitions.

2.3.5 Pressure Sensors

Pressure sensors are either used solely or in conjunction with other technologies (Chen & Nugent 2009). These sensors are mainly used to check the presence of the elderly in chair, bed or within the house (Dutta & Dutta 2013) . They detect the amount of pressure on grab bars or area of contact to record time for transfers from sitting to standing position or vice-versa. The aim of monitoring is mainly to detect the presence of the elderly.

2.3.6 Sound Recognition

Sound technology is specifically designed and used to track sounds that could indicate different activities of the elderly (Amiribesheli, Benmansour & Bouchachia 2015; Calvaresi et al. 2016; Rashidi, Diane J. Cook, et al. 2011). They use microphones to detect different daily activities, for example, activities like playing music etc. Previous studies indicate the use of sound recognition for monitoring the significant activities of the elderly living at home.

2.3.7 Smart Home Technology

Smart homes are defined as any living environment which is designed purposely to assist people in conducting daily life activities (Ricquebourg et al. 2006; Cook & Schmitter-Edgecombe 2009). It consists of various sensors installed in its premises which can maintain the temperature, lightning and automate the working of electronic devices in the house. These sensors operate on a given network and data is collected at a remote location for monitoring and regulation.

In the previous studies, all smart home environment concepts were developed to detect the activities of its occupants, and in order to maintain the environment according to the user needs.

2.3.8 Robotic Technologies:

The mobile robots are mainly used for providing at-home therapy to the elderly patients. The development of mobile robots in context of AAL have been by previous studies (Brady, Sterritt & Wilkie 2015). Mobile robots monitor the health of the elderly and assist in the treatment at home. However, the accuracy of the robots is not yet declared as it is a very new advancement in the field of AAL. These technologies have been found to be used either in different combinations of other monitoring technologies or in conjunction with medical equipments (Smarr, Fausset & Rogers 2010).

2.4 Designing AAL Components

Previous studies on user-centred technologies have provided suggestions for designing the applications for the older generation. Ambient Assisted Living Association provides a comprehensive knowledge base on basic user requirements to improve the adoption of AAL solutions, and reduce the gap between technical and economical requirements as discussed in the following section (Nedopil, Schauber & Glende 2013b).

2.4.1 Sensors and Data Collection:

While motion sensors (e.g. PIR) or contact sensors (e.g. for entryways) are generally acknowledged among the clients, while the utilization of cameras or audio devices are less supported. Regardless, even if the cameras or microphones were to be introduced, location is the main factor for their acquisition (e.g. in the lounge room, yet not in the washroom). As to sensors, venture groups need to consider that seniors – particularly the individuals who live alone – might have pets at home that could meddle with a framework's recognition.

Deployment of sensors

Making holes in the wall or laying links for connecting devices are main shortcomings for most users (but wireless connections can be used instead e.g. using EnOcean or ZigBee). They expect to utilize the system in their current home, and don't want to move to another home just to utilize AAL arrangements. However, it is suggested that aesthetics should be considered, and that sensors be placed unobtrusively (in accordance with the notion of "ambient" assistance). It is also important to ensure that the electricians share this idea if the installation of the sensors is done by a third party other than the main service provider.

Apart from the generic ethics regarding the data storage, it is important to know the perspectives of the users (seniors) regarding the data sharing and feedback. A lot of then do not like to share the data regarding their health with their family members apart from the emergency situations or sharing good memories. Also, they do not want feedback from all the recorded data, for example, activity pattern. The decreased accuracy or false emergency alarms is another system issue that the seniors are less tolerant about. They would prefer long detection timing over false alarms.

2.4.2 Hardware and Interface

A scope of design guidelines has been initiated to incorporate the necessities of disabled individuals in the design procedure, for example, Universal Design, Design for All and Inclusive Design (Story 1998). These recommendations have set down basic principles that can be used for designing AAL tools for the older people or even for dementia patients. It can be used as a practical guideline for designing user-centred technology for users with special needs, despite the fact, that it might not be possible to meet all proposed guidelines (since some may be opposing).

For instance, the principles of the Universal Design approach are as follows (Story 1998; Nedopil, Schauber & Glende 2013b):

- Principle 1: Equitable Use

The design is helpful and marketable to individuals with various capacities, without stigmatising those with special needs.

- Principle 2: Flexibility in use

The outline suggests that different methods of use should be given by the design to match individual's needs and capacities. Example: Right-handed or left-handed access and use.

- Principle 3: Simple and Intuitive

Use of the design is straightforward, regardless of, user's experience, learning, language aptitudes, or current focus level.

- Principle 4: Perceptible Information

The design conveys vital data adequately to the client, regardless of the ambient conditions or the users' sensory capacities.

- Principle 5: Tolerance for Error

The elements of the design should be arranged in a way that limits hazards and the errors resulting from accidental or unintended activities. The design should be able to provide warnings of hazards or have fail-safe features.

- Principle 6: Low Physical Effort

The design can be utilized productively and comfortably and with least exhaustion. It should minimize repetitive actions and sustained effort.

- Principle 7: Size and Space for Approach and Use

Appropriate size and space is accommodated for easy approach or reach of devices, control of devices, and their use regardless of the user 's body size, stance, or mobility. It should also provide adequate space to hold the assistive device or for personal assistance.

Apart from the general standards, some specific guidelines are there for the design of other assistive devices such as wheelchairs, alarm systems or smart homes. Some of the international guidelines that can be helpful for the development of AAL devices:

ISO/IEC Technical Report – availability and ease of use for biometric frameworks.

ISO9241 – a multipart standard with various arrangements focussing on programming, physical input gadgets and ecological elements

ISO 28803 – the ergonomics of the physical condition; use of global models for individuals with special needs.

CEN/CENELEC Guide 6 – rules for engineers to address the necessities of older people and people with disabilities.

From an ergonomic point of view, the accompanying viewpoints should be considered for the AAL hardware design. Some of them are listed below:

- Low energy utilization
- Visible on/off switch
- Adequate size of equipment hardware for easy handling
- Adequate size of controls for error-susceptible usage
- Simple to press/utilize controls or buttons
- Single use of controls
- No foreign language or complex labels for the controls
- Easy to read labels, even in bad illumination
- Conspicuous and natural signs and images of controls
- Cautious plan of controls to avoid complexity or undesirable operation of related components
- Flexible multimodal feedback
- Simple-to-clean device
- Aesthetic design

Another imperative feature (e.g. for field trials) is easy to read and understand manual that compactly portrays the most important functions, with text or figures. For the market dispatch of an AAL item, packaging of the device should be easy to open. It is also important to note that a user-friendly design does not only allude to showcases or interfaces, rather also design hardware according to the seniors' needs.

For an adaptable interface, apart from designing large buttons, various modifications can be helpful for the elderly. ISO standard 9241-110 defines seven

principles as guidelines for building user-friendly and interactive software systems (Naumann et al. 2007) as discussed below:

1) Appropriate for the job: The dialogue should be able to support the user in completing a task and should only display the information related to the users' task.

2) Self-descriptive: A dialogue should be self-expressive. A dialogue should be understandable with every step through a prompt response from the system, or it is explained to the client when asked.

3) Controllability: A dialogue should be able to support controllability. It is supported if the user is able to follow the instructions and operate the device until their objective is met.

4) Conformity with client desires: The dialogues should accommodate client desires. It should conform to the users' understanding of the task, their experience, education and to generally held beliefs.

5) Error resistance: A dialogue should be error tolerant. It should be able to accomplish the proposed results with no or insignificant remedial activity. Errors should also be explained to the client for him or her to rectify them.

6) Suitability for individualisation. A dialogue should match or cater for individual needs. The dialogue system should adjust to the client's individual needs and aptitudes for a given task.

7) Suitability for learning. A dialogue should be able to direct the client through the learning stages, limiting the learning time.

Since these necessities are intended to be appropriate for each conceivable interface, they are kept on a general level. It is up to the designers to characterize the importance of these standards in a given application (e.g. (Pak & McLaughlin 2010). More specific guidelines and recommendations have been discussed in previous studies to develop interfaces for the seniors. These suggestions are directed to support different dimensions of users: Vision, hearing, mobility and cognition. However, following the guidelines doesn't ensure the acceptance of the

devices as elderly people are still new to the AAL technologies. Thus, testing the devices with users is important before launching a device on a bigger scale. It also ensures the needs of the elderly are accommodated and thus, improves the acceptance of these applications.

2.4.3 Robots and Automation:

Serving Robots' configuration is profoundly subject to the tasks the robot needs to perform: moving things around (arms, wheels, positioning) and interacting (tuning in, understanding, talking) all have distinctive specialized prerequisites. Blow et al. describes the dimensions for human-robot interaction in the design of robots (Blow, Dautenhahn, Appleby, Nehaniv & D. Lee 2006; Blow, Dautenhahn, Appleby, Nehaniv & D. C. Lee 2006) as follows:

- Robot traits (e.g. appearance, identity)
- User's personal characteristics (e.g. age, sex, mental health status)
- The task performed (e.g. measuring blood pressure, serving drinks).

Thus, giving general directions on robot configuration has no grounds. However, it is crucial for robot designers to consider not just the specialized parameters while making a robot, but also the human factor: How does the client see the robot's appearance and conduct in a given circumstance? For example, rather than moving at a speed that is technically ideal, it may be smarter to reduce a robot's motion to a level with which individuals are agreeable, hence, upgrading consistency and wellbeing. Therefore, engineers should check what feeling the robot (or symbols) summons in their clients (Broekens, Heerink & Rosendal 2009).

One noteworthy issue that requires close rumination is the robot's humanoid attribution. Although robot turns out to be more affable if its appearance and movements are human-like, yet only to a specific level. Beyond a certain level, human-like robots may trigger revulsion and spookiness.

Moreover, it is necessary to coordinate a robot's appearance with its capacities. For example, a (human-like) appearance may imply that the clients expect

activities that the robot can't actually satisfy (e.g. tuning in and talking), despite the fact that it has a human face.

Following issues need to be considered when outlining robots, depending on the targeted users and the scenario (Wada et al. 2005; Nedopil, Schauber & Glende 2013b):

- Humanoid attribution: make a robot not very human-like, rather predictable with its capacities
- Size: test an agreeable estimate for clients, which relies upon its errands and the client's position (e.g. sitting versus standing)
- Discourse: utilize human voices rather than imitated/fake speech
- Feelings: make the robot enjoyable to utilize, yet be mindful so as not to bring out doubtful assumptions about its capacities
- Identity: should coordinate the client's identity; a genuine identity upgrades client compliance
- Timing: guarantee timing, particularly with respect to correspondence and response times to users' instructions
- Security: avoid undesirable contact or collisions
- Self-sufficiency: a robot should be intended to help in basic circumstances or help with proactive social conduct; other activities (e.g. administering drug) should be left to other professionals (e.g. a physician, nurses etc.).

Apart from the above recommendations, ethics needs to be considered in terms of human-robot interaction. It is mandatory that engineers also take into account the social ramifications of using robots in individuals' private home: What happens when a robot separates or is removed? Is the connection amongst human and robot planned to be one of ace and slave? Could a robot disparage the individual for whom it is supposed to support? These issues need to be taken into account while designing robots in AAL context.

2.5 Users of AAL

The beneficiaries of AAL solutions are wide-ranging. The main end-users are the elderly who directly benefit from the aiding technology which is aimed at helping the older people live longer and healthier in their desired environment. The

requirements of the senior citizens depend on the functional disability faced by them which could range from physical to mental health problems. The users targeted by the AAL industry has broadened over the course of time (Aumayr, Bleier & Sturm 2017). Even though AAL devices were initially built to increase the mobility of the older people and to help them live independently at home, the focus of the AAL industry has now shifted towards the other users as well. The secondary users are the people associated directly with the elderly like family members, relatives, friends and professional caregivers and care institutions. While the tertiary users include those indirectly related to the older adults and make these applications available to them. This includes the public health organizations (e.g. hospitals), insurance associates and public security firms (Broek et al. 2010; Sun et al. 2009; Nedopil, Schauber & Glende 2013a).

The primary end users of AAL technology have more specialised requisites for usability and desired services as compared to other users. The elderly have numerous requirements but the most essential and desirable benefits being sought from the use of AAL technologies are the independent living and ageing in place(Jaschinski & Allouch 2015). While seniors with dementia are one of the frequent target group for AAL applications, they are regarded as extreme user group as they have very specific requirements according to their special needs (Mihailidis & Fernie 2002). It is important to be aware that dementia is a degenerative disorder, and symptoms vary according to its stages. They experience different cognitive and behavioural symptoms of dementia. Cognitive symptoms include reduced memory, the power of judgement, learning capacity and sometimes, distorted speech. While behavioural symptoms include agitation, apathy, hallucinations and different levels and types of depression. Thus, these users need AAL solutions with context awareness that are able to cater for needs in different areas of symptoms (mobility, memory, hygiene, eating habits, interaction, and daily life activities like washing, dressing, walking etc.) at different stages of dementia. Thus, dementia patients require the solutions to cater not only for behavioural aspects but also for emotional aspects of their life.

The requirements of secondary users (children, relatives, spouse, friends, predominantly women) vary from the other users. Their preferences are typically

inclined towards communication, monitoring and emergency alerts, support with administration tasks (Nedopil, Schauber & Glende 2013a). Informal carers provide support to those requiring care with a variety of activities: medication, mobility, cooking meals, feeding, toileting needs, dressing, watching at night, daily life activities like shopping, laundry, cleaning, and social communication. The intensity of care given by caregivers vary in different countries. Low care demand from the elderly is manageable by some caregivers. Rather, sometimes caring for the other person gives them a sense of achievement, satisfaction and personal growth. However, as the intensity of provided care increase, it starts affecting caregivers' work life due to stress and inadequate sleep and in some cases, they give up jobs, which also lead to financial pressure on them (Kenny, King & Hall 2014). Relatives often suffer from mental health issues as they are unable to balance their own needs with the responsibility of caring for another person (Rashidi & Mihailidis 2013; Costa, Novais & Simoes 2014). Since the informal carers are involved in the purchase and use of AAL solutions, their needs should also be met by the applications, and ideally, the functionalities of these devices should fit into their daily routines (Pino et al. 2014). Professional carers like medical professionals (e.g. nurses, doctors, physiotherapists) are motivated by societal issues like reducing the length of stay for patients in the hospital. They are expected to have increased mobility according to present work settings, be friendly and empathetic to the patients, keep records and be updated with the current scientific research and comply to the latest technology standards and usage. They also have to deal with the safety of the patients and document numerous records as part of their job. Thus, it can be burdensome to work in the care industry with a huge workload, psychological stress, time limits and constant requirements to update the relatives of the recipients of the care. Medical professionals have the authority to access the medical devices the data from the sensors. Thus, it is imperative to include them in the developmental process of AAL solutions. Additionally, AAL solutions should also integrate the needs of the professional caregivers keeping in mind that the technology should be easy to handle and less time-consuming in its usage.

Other stakeholders like different therapists, rehabilitation centres, real estate developers, architects and insurance firms should also be included in the

developmental process of AAL devices. They hold practical insight into the financial costs, required time, quality of service, design of AAL devices and crucial information for the successful deployment of these devices.

However, in the coming future, AAL technologies will be mainly utilized by the senior citizens. Thus, the elderly should be considered as the main target group in terms of incorporation and interpretation of the requirements. The methods such as stakeholder analysis and business canvases are useful to develop project and business plans in order to scrutinize the integration of requirements from the different end users (Wallin & Pussinen 2017). It has been noticed from the previous projects that the involvement of end users during the development has been helpful in increasing the uptake of AAL technologies (Pino et al. 2014; Peruzzini & Germani 2014; Davidson & Jensen 2013b). Thus, it is important to recognize which end users should be involved in a particular project for requirements definition. This will eventually lead to increase in the output. However, it is also important to avoid any assumptions or bias about the digital literacy and other factors among the elderly while designing AAL devices. The older adults' ability to use technologies vary in different parts of the world. For example, in developing countries, the access to technology is not as widespread as in developed countries. It is also important to note that the trend towards living independently among senior citizens is accelerating and will continue in future older cohorts (Nedopil, Schauber & Glende 2013a). Previous studies suggest that there is a connection between aging, socioeconomic status and health (House et al. 2016; Sun et al. 2016). Thus, it is important to consider the socioeconomic factor while considering the requirements definition for AAL applications. The requirements of the targeted group become manifold when the typical factors like income after retirement, increased risk due to age-related impairments, changing lifestyle and living conditions are taken into account (Aumayr, Bleier & Sturm 2017).

While there has been significant research on the development and improvement of the AAL technologies (Demiris & Hensel 2008; Queirós et al. 2015), minimal research has been conducted on user acceptance and uptake of these technologies (Alsulami & Atkins 2016), and particularly within Australia (Hara et

al. 2015; Gill 2011). The use of these technologies, in the real world, is still limited and thus, it is imperative to explore the major hindrances to the adoption of these technologies (Rashidi & Mihailidis 2013).

2.6 Barriers to Acceptance of AAL Technologies

AAL has received strong attention in the past decade and been considered to have the potential to cater for the needs of the elderly as well as for meeting the challenges faced by the government due to changing demographics (Huldtgren et al. 2014; Alsulami & Atkins 2016). Nonetheless, the adoption of AAL by the elderly is a big issue with regards to their practical employment. Thus, addressing the barriers in the use of AAL technologies plays a major role in decreasing the gap between policy encouragement for AAL and their implementation.

Despite the fact that exploration on AAL advancements is, as of 2017, a new and rising field, a few analysts have investigated users' view of AAL applications (Demiris et al. 2004; Steele et al. 2009; Bradford et al. 2017; Beer, Chen & Rogers 2017; Lai et al. 2010; Hsiche 2016; Alsulami & Atkins 2016; Mahmood et al. 2008).

Most elderly people prefer to stick to their old lifestyle and resist the new changes, maintaining tradition. To increase the employment of AAL technologies, understanding the intellectual needs of the elderly is vital. This includes their personal needs, habits, quality of life and their digital literacy. Meuter mentions that outside control, manipulation and self-aggregation are examples of what people dismay about technological innovation, in the sense they are subtle and unconscious (Meuter et al. 2003). The present types of innovation resemble early, tactless endeavours with rats, and that there is no possibility to escape, from the compulsion of accepting technologies forced upon users. However, with respect to the feelings of trepidation that may emerge while presenting new types of communication, training and lifestyle, the challenge is to exploit the numerous conceivable outcomes that innovation and media creations and advancements involve. In this way, creation and allocation should be reflected fundamentally. Faith in technologies creates the premise for development, but, they must also accommodate for expected issues and fears. When looking at managing innovation, one critical point is "acceptance" in the field of psychology.

Individuals need to acknowledge technology to utilize them routinely. Especially elderly individuals who are regularly perplexed of innovation in the light of an absence of experience. For the younger generation, there won't be the same number of fears as they are familiar with the use of technology in all aspects of life. Older individuals, frequently, are not acquainted with controlling and utilizing innovative gadgets and thus, are hesitant. To adapt to this issue, decisions concerning the kind of innovation or media, planning and utilisation are fundamental.

The IPTV (Internet protocol television) project in Austria has tried to highlight the needs of the elderly to be addressed by the AAL innovations. The author has emphasized the importance of multidisciplinary access to the research and development realms of AAL, instead of being confined to technological or media fields (Fuchsberger 2008). The Age Lab from the MIT has also included social and cultural perspectives in addition to technological for AAL innovations (MIT AgeLab 2017). Another study examined if there is an important connection between the older adults' trust and the type of support integrated into an AAL solution (Steinke, Ingenhoff & Fritsch 2014). The investigation was done through an experimental set up to differentiate between two type of support function: Personal Remote Assistance (PRA) and Embedded Technical Assistance (ETA), provided to the elderly for using an AAL application on a tablet PC. The author has made suggestive remarks about the link between trust in AAL technology and ease of use. The study also revealed that the participants were, in general, curious to know about innovative technology. However, low usability was the main reason with respect to the trust in AAL for people to have a lower inclination towards technology.

Another psychological factor that acts as a barrier to the uptake of AAL devices includes the need for human interaction among the users. A study suggests that the elderly fear the loss of human interaction and rejects the replacement of families and friends with machines (Salber, Dey & Abowd 1999). Huldtgren et al. outlines the role of a mediator for increasing the acceptance of AAL technology among the elderly (Huldtgren et al. 2014). Due to technologically focused developments, there is gap between policy enthusiasm for AAL and its limited

influence in practice. As a result, technology is often imposed on older adults by health professionals, family and policymakers. Thus, the authors proposed a method of introducing AAL to the people by displaying practicable benefits of a system fulfilling needs of elderly via a mediator. A mediator is an explicitly designed semi-technical installation presenting AAL system through which people can interact. The authors conducted an exploratory study to know the needs of elderly for designing a mediator prototype. Finally, the article addresses three important issues while designing the mediator: self-efficacy, anticipatory living, peer support.

One of the few reasons for the rejection of AAL technologies is the primary users' lack of experience in using the technology. They feel terrified to use the technology as they are unable to choose the right technology according to their needs. Heinz et al. examined the older adult's perception of technology using Glen Elder's (1974/1999) life course theory and Rogers' (2003) theory of diffusion of innovations. There are many variations and improvements that occur throughout a current elderly's life. From the life course theory point of view, authors believe that current older adults have less probability of being aware and make use of technology in their everyday life. It is simply because of the time period in which they were born and the historical events they've experienced (Heinz et al. 2013). Digital literacy and increasing awareness about the benefits of different technologies will help the elderly people choose better and decrease the resistance in using AAL technologies.

Few studies in the past have suggested that privacy has been one of the primary concerns among the elderly. They are worried about the misuse of their personal data and not comfortable being monitored by video cameras. Thus, research to address the trade-off between privacy and benefits needs to be undertaken. Security issues under the umbrella of AAL are still under question. Data could be stolen or lost because of the weak security systems in some of the AAL applications like home security systems used to monitor elderly people. Often wearable sensors and implantable devices are controlled by the industrial vendors and the data obtained are confined to them, while ignoring privacy of patients' data and their rights to access their own data. However, the seniors are

now more aware of not just the new technologies, but also about the security and privacy issues like misuse of their personal information through hacking. Thus, to increase the adoption, it is important to engineer privacy and security into the AAL solutions.

Demands of the elderly people to live independently have made home security one of the fundamental needs as they remain unshielded from dangers. The most prominent issue in terms of safety has been the falling. Fall detection systems were developed to monitor them using wearable sensors. But wearing sensors all the time was a problem which made them unreliable. Thus, floor and door sensors have been developed in combination with video detection for their safety. The adoption of AAL technologies is highly dependent on creating a safe environment for the seniors as a lot of them connect home environment to healthy ageing (Sixsmith et al. 2014). The concept of "Ageing in place" is aimed at promoting the autonomy, well-being and participation of the older people whilst living in their own home and community setting, withal, also reducing the cost for institutional care (Grabowski 2006; Bryant, Corbett & Kutner 2001). Smart homes are designed to aid the ageing in place (Morris et al. 2013), but their adoption among the elderly and carers still remains in jeopardy (Clark & McGee-Lennon 2011; Balta-Ozkan et al. 2013; Peek et al. 2014; Kendig et al. 2017). A Taiwan-based research investigated needs of the elderly to improve the home care services using modified Delphi method in two phases. The author categorizes the concerns of the older adults into five physiological needs: needs for love, belonging, security, esteem and self-actualization.

Steinke et al. carry out the numeric investigation of trust in automation and home assistance systems through a literature review to know the overall requirements of the older adults (Frederick Steinke, Tobias Fritsch & Lina Silbermann 2012). The study shows that the trust in medical technologies occurs- not only in the connection between doctor and patient or patient and technology. In fact, there is a complex matrix of connections, which eventually forms a 'network of trust' in technology use. In the article, the authors have focused primarily on the importance of trust in assistive technology for elderly people.

The user-friendliness of the technology is very important for adoption of AAL technologies. Elderly people are likely to reject the technology simply because they find it very hard and complex to use the system. For example, a study suggests that they prefer to use smaller robots (Smarr et al. 2014). The size, user-interface, and pleasant experience affect the practical use of robots by the elderly. Thus, the overall design and user-interface of the technology also affect the adoption. The lack of standardisation amongst different AAL devices reduces the interoperability. This increases the difficulty in the use of AAL devices from different vendors. Thus, creating a common platform to allow interoperability between sensors, appliances, applications and security systems will be highly useful in increasing the adoption of these technologies.

Finance is one of the most dominant factors affecting the acceptance of AAL technologies by elderly people. Due to negligible income, some elderly people are not ready to pay a large amount of money to use these technologies irrespective of the benefits. They assume the support from the government and expect the technology to be affordable to them. Through previous studies, the cost of the devices, their deployment, energy use, repair and maintenance have been identified as the barriers in acceptance of AAL devices (Peek et al. 2014; Arnold et al. 2013). Hence, it is important to address these challenges, impediments and issues to increase the acceptance of AAL technologies among the end users.

One of the ways to increase the acceptance is to design the technology according to user needs. Developing the user interface and design of AAL technologies through the participation of the elderly will give them a chance to explore the technology as well as give a clear picture of their needs to the technology designers. Davidson and Jensen try to accentuate the importance of the participatory design of healthcare applications in their work. Many technology designers ignore the needs of older adults and often focus on technological advancements. The authors purposely included elderly in the design of a healthcare application. Questionnaires and participatory design sessions were conducted to comprehend the end-user perspective. Finally, the authors answered the proposed research question by summarizing the main health metrics elderly want to track: social interaction tracking, rest tracking,

suggestions for local stress-relief activities and suggestions for eating better (Davidson & Jensen 2013a). Although the article uses intensive methodologies to pinpoint the major gaps in the AAL industry, it is a dynamic process. Therefore, the limitation of the used methodology is that the coming generation will have different perspectives and needs as compared to the present, therefore, similar studies should be continued in future. Agilani et al. found that the use of ICT platform for healthcare was helpful for the elderly and it gave them a sense of independence and ease in interacting with registered nurses. The authors highlight the idea of person-centred care using ICT technologies for the future development of AAL technologies. Patient-reported outcomes have been found useful by the medical professionals to improve health outcomes for the seniors.

A number of administrative issues posture obstructions in the deployment of the sensors in the smart homes. One of the main challenges addressed from previous projects is the ability of smart homes to integrate and evolve into the design, lifestyle and general feeling of home (Stringer, Fitzpatrick & Harris 2006; Edwards & Grinter 2001; Brauner, van Heek & Ziefle 2017). Technological innovations that does not fit in their home environment, is improbable to draw homeowner and customer's interest and may instead give them the impression of the technology as "uncontrollable". Balta-Ozkan et al. investigated social hindrances to the acceptance of smart homes through the examination of public attitudes and expert views. Loss of apathy; reliability; interoperability; viewing smart home technology as divisive; privacy and data security; cost and trust were found to be the main concerns to the adoption of smart home services and products (Balta-Ozkan et al. 2013).

The older adults face various issues while using technology in the daily life. When considering AAL technology, that some of the seniors are yet to discover or use, they present different concerns. While AAL technologies have the capacity to aid seniors in many ways, however, the negative aspects often outweigh the benefits. To begin with, the unawareness of the AAL technologies itself has proven to be an issue in their acceptance.

Reviewing of literature shows that previous work has tried to know the user acceptance and trust in AAL technologies (Yu & Comensoli 2004; Arning & Ziefle

2009; Frederick Steinke, Tobias Fritsch & Lina Silbermann 2012; Queirós et al. 2015; Vaziri et al. 2016). Previous studies show that the major barriers and challenges in the adoption of AAL technologies connect to one of the following factors:

2.6.1 Lack of Awareness and Digital Literacy

Unawareness about the benefits of technology is the most common barrier among the elderly people (Loh, Flicker & Horner 2009). One of the concerns raised by the older people in the past was the lack of experience in choosing the right technology. They not only lack digital literacy to use them, but they are also not aware of the benefits of learning to use them. According to technology acceptance model, commonly used for studying end users' reactions to health information technology, perceived usefulness and perceived ease of use has been reported to be the main determinants to measure end users' perspectives (Holden & Karsh 2010). Older people have expressed that they would use the technology if they found it useful, however, with less specification to what the usefulness means to them (Peek et al. 2014). "*If the thing is good and it works, then we go for it. However, if we see something that is useless, and obtrusive, and is change for change's sake, then no. Not interested*" (Steele et al. 2009). While in other instances, seniors' interests are more clear, with improved independence and increased safety being indicated most frequently (Steggell et al. 2010).

2.6.2 Ease of Use and Human Contact

Most elderly people stick to their old lifestyle and refuse to accept any changes in their behaviours or daily life. They also fear that the uptake of these technologies could lead to a reduction in human interaction (Alsulami & Atkins 2016). This was also supported by the fact that they would like to use the They don't want technology to replace the communication with the family members, friends, nurses and others.

2.6.3 Privacy

The elderly people are worried about the misuse of their personal information and resist from being monitored by cameras and other forms of technology

(Celler et al. 1995). Even though privacy has been recognized as an issue, a few studies have demonstrated that occupants will exchange privacy for the self-sufficiency given by living in their own homes (Townsend, Knoefel & Goubran 2011).

2.6.4 Lack of Financial Support

The lack of government support is one of the major barriers (Peek et al. 2014). The elderly people are unwilling and sometimes incapable of accounting for the money needed for installation and maintenance of the technological devices.

Home safety and security, the lack of training, size intrusion and weight intrusion of technological devices, family acceptance and culture are the additional factors that hinder the acceptance of AAL technologies among the end users. However, there is a lack of similar studies within Australia. Thus, there is need to undertake the thorough study for knowing the major issues, within the context of designing these technologies.

This study investigates the major barriers preventing older Australians from using these technologies. The main aim is to demonstrate the major issues faced by elderly Australians as the primary objective of the research. The secondary objective of the study is to explore, in detail, the factors that have never been addressed in previous studies (most of which have been done elsewhere). The study elicits the results in terms of the user needs for technology design. It is relevant to mention that the study aims to understand the concerns, attitudes and preferences of the users from a technology perspective rather than a psychological point of view.

3. METHODOLOGY

Interactionist studies are one of the most efficacious ways of conducting qualitative analysis (Steinke, Ingenhoff & Fritsch 2014). They are helpful in investigating the perspectives of the participants in different scenarios. According to the theory of interactionist, different beliefs and opinions are evolved based on the interactions within a group. However, these kinds of studies are more common in sociology. In order to comprehend the behaviour or perspectives of users towards the technology, investigating their understanding and interpretation of these tools, in legitimate settings, is essential (Murphy et al. 1998). Thus, quantitative approaches alone are not enough to study this kind of empirical phenomenon. Delphi technique and Quality Functional Deployment are one of few operative techniques for conducting this kind of research (Hsiche 2016; Peruzzini & Germani 2014). However, the project does not uptake these techniques because of time and resources constraints.

The project has used mixed approaches through a combination of quantitative approaches including written questionnaire (Alsulami & Atkins 2016) and qualitative method such as focus groups (Peek et al. 2014). At first, a literature review was conducted to understand the barriers to adoption of AAL technologies as addressed in the previous works (Peek et al. 2014; Frederick Steinke, Tobias Fritsch & Lina Silbermann 2012; Rashidi & Mihailidis 2013; Steinke et al. 2012). The knowledge drawn from the literature review conducted on the types of existing AAL technologies was also utilized. A user-persona was developed to design the themes for the questions to be asked in the focus groups conducted within the targeted population (people above 65 years of age). Open-ended questions were asked in the focus groups deliberately to avoid the biasedness of research from closed-ended questions in the questionnaire (Vaziri et al. 2016; Arnold et al. 2013). The questionnaire consisted of four types of questions: open-ended, closed, follow-up and prompted questions. It was designed with an aim to cover the main themes derived from the literature review. The questionnaire was developed inductively to expand the data size for the study, to obtain more accurate demographics of the participants. The authentication and reliability test of the written questionnaire was done using

Flesch–Kincaid readability tests and reliability test such as split-half test. Content analysis was done followed by transcription using the qualitative data. The analysis for the questionnaires was done using Microsoft Excel for data visualization and summarization of the results.

3.1 Recruitment and Selection Criteria:

The recruitment of the participants for the focus groups and questionnaire was done through recruitment flyers in the retirement villages. The information sheet (attached in Appendix A) was also distributed to the interested participants which described the aim and overview of the project to the participants. It also described different ethical aspects like rights of the participants to withdraw anytime and other human ethics were followed to conduct the research. Out of over 100 eligible seniors who were informed, 25 interested participants signed up to participate in the research. The interested participants were encouraged to sign up at the reception of the retirement villages after reading the information sheet on the project.

The main selection criteria to recruit the participants were indicated on the recruitment flyers (attached in the Appendix A). The selection criteria included the age of the participants to be above 65, their ability to understand English and to be able to consent independently. This was also confirmed through some of the questions in the written questionnaire to obtain more accurate demographics of the participants.

3.2 Introductory Sessions:

Prior to the focus group discussions and filling out the questionnaire, an introductory session was held to acquaint the participants with the ambient assistive living technologies and their functioning. The introductory sessions included the videos and presentation on the AAL technologies, feedback and answering questions from the participants, followed by a general discussion among the participants.

The video included AAL technologies like smart homes shown through example of an assistive living facility in USA called Elite Care, Respite robots in a Melbourne nursing home, wearable technologies for health monitoring from

Intel, a walking assist device from Honda, Lifeline Phillips- an auto alert device for fall detection and emergency, a Medication dispensing device by Phillips. The video also had clips of researcher briefing the purpose of this research. After the video, the participants were involved in the discussion and asking questions from the researchers. Following this, the participants were engaged in the focus group discussion based on five themes. Following the focus group discussion, images of Assistive devices and technologies were shown in the PowerPoint presentation to the older people. Some of the AAL technologies that were shown through the images (also attached in the Appendix B) includes devices like Google Home, automated remote control for home appliances such as LED lights and TV, fall detection systems, serving assist devices, and personal care aid devices. Some of the basic assistive devices were deliberately included in the presentation to show the devices and aids already available in Australia. Surprisingly, not everyone was aware of them or knew how to access them even if the seniors perceive them as useful to improve their lifestyle.

Before the start of the session, participants were asked to sign the consent forms (attached in the Appendix A) which confirmed their consent for audio recording and filling up the written questionnaire. The audio recorder was turned on after the information session and signing up of the consent forms. However, as outlined in the ethics approval (refer Appendix A) from the Human Research Ethics Committee (HREC), no personal information was recorded at any stage of the research and ethics were followed scrupulously for this study.

3.3 Focus Groups:

Qualitative data was collected through three focus groups conducted at three different Anglican Retirement Villages (ARV, also called Anglicare) in NSW: Caddens village, The Ponds village, and St. Stephen's village. The focus group discussion was based on five main themes which were drawn from the literature review done on the barriers to acceptance of AAL technology among older people. Before the beginning of the focus groups, the video on the introduction of AAL technologies was played. The five questions for the discussion focused on identifying main barriers to acceptance of the AAL technologies, their general perception about them and preferences in terms of using them in future. It gave

a more informed understanding of the needs of the end-users and how the challenges in acceptance of AAL technologies depicted from the study, could be addressed in the future. Some of the links between various socio-economic dimensions and seniors' interest in AAL technologies was found through the data. The audio recordings were transcribed followed by content analysis. All participants who were recruited initially agreed to take part in the study. All respondents are from NSW-region and Australians. On average, each focus group discussion combined with feedback session on AAL technologies lasted for about 1 to 1.25 hour.

3.4 Written Questionnaires:

A written questionnaire was composed inductively based on the knowledge derived from the literature review conducted on types of existing AAL technologies. The main aim was to determine the factors that limit the acceptance of AAL technologies among older Australians.

The questionnaire was available in English language only and was conveyed to the participants through the printed version. The researchers were reachable to help the elderly individuals to fill in the poll or to answer any inquiries they had with respect to it. As specified before, the survey comprised of four types of questions.

Firstly, there were six dichotomous questions to get distinct values about the opinions of the elderly about AAL technologies. Secondly, there were fifteen multiple-choice questions, most of which were similar to the Likert-scale measurement, to determine the extent of the seniors' attitude towards AAL technologies. Thirdly, the questionnaire included three "fill in the blanks" type questions to record accurate demography of the participants. Finally, there were optional open-ended follow section to add comments to the answered questions, regarding the preferences and concerns of the elderly. There was a total of 24 units in the questionnaire. The questionnaire was categorised into four main divisions: demography of the participants, barriers in the uptake of AAL technologies, concerns and preferences in use of AAL technologies. The acceptance rate of the survey was quite high with 72% participants answering the full questionnaire. While 21 questions (88% of the total questions) were

answered by all participants. Quantitative information was examined through elucidating insights as frequencies and rates utilizing the Microsoft Excel software. The following figure (figure 3) briefs the methodology:

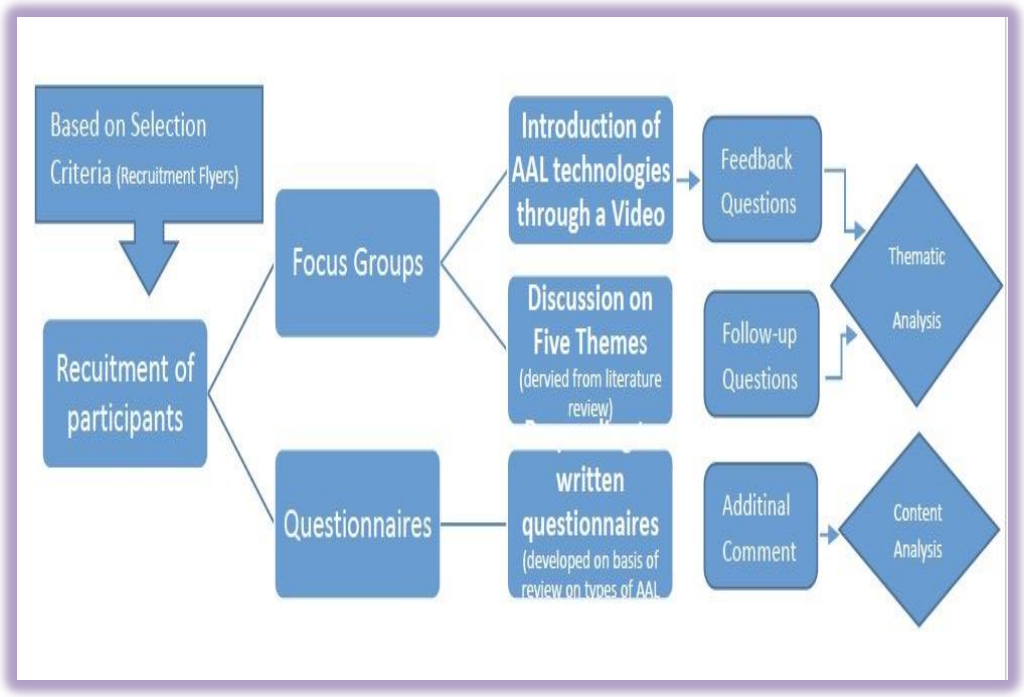

FIGURE 3: METHODOLOGY

The participants were introduced to AAL technologies through a video showing examples of existing technologies such as smart homes, wearable sensors, respite and assistive robots, technology operated assistive devices, medical dispensers, emergency auto-alert systems, and other available assistive devices like Google home. The images in the appendix B and C are from some of the technologies shown in the video.

As given in the questionnaire script attached in the appendix A, a few questions were aimed to know different themes. Some open-ended questions were added to know feedback and additional views of the seniors that were not included in the focus group and the questionnaire. The open-ended discussion was carried out in four focus groups deliberately to avoid the biasedness of the research methodology arising from the closed-ended questions.

3.5 Demography of the Participants:

All 25 participants who were recruited initially, agreed to take part in the study. The data analysis infers that the majority of the participants were female (68%), whereas males accounted for 32% of the total participants (*n*=25). The participants included in the study aged between 67 and 89, all of them with Australian background and 96% have English as their first language. 40% of the participants are school leavers, 20% have vocational degrees, 16% have bachelor's degree and while one of the participants have a doctoral degree (4%). All the participants live independently and are from Greater Sydney region.

Table 3.1: Demography of Participants

CHARACTERISTICS	NUMBER OF PARTICIPANTS
AGE	
67-74	4

75-90	19
GENDER	
MALE	8
FEMALE	17
FIRST LANGUAGE	
ENGLISH	24
NOT-ENGLISH	1
EDUCATIONAL QUALIFICATION	
SCHOOL LEAVER	8
INTERMEDIATE	2
SENIOR SCHOOL CERTIFICATE	3
VOCATIONAL EDUCATION	6
BACHELOR DEGREE	4
POSTGRADUATE/DOCTORATE	1
ETHNICITY	
AUSTRALIAN	18
OTHERS	7
PLACES LIVED	
AUSTRALIA- REGIONAL	1
AUSTRALIA- URBAN	22
LIVING CIRCUMSTANCES	
INDEPENDENT	25
FAMILY SETTINGS	0

4. RESULTS AND FINDINGS

The study discovered new findings on the barriers, concerns and preferences for older Australians in the adoption of AAL technologies, in addition to those identified by previous studies. Some of the findings are in line with the previous

studies while there are a few newly discovered findings from this project. The main barriers to the adoption of AAL technologies among older people that align with previous studies are the lack of human contact, the lack of perceived usefulness, the lack of awareness, digital literacy as well as cost. While some of the factors that were found additional to the existing ones were found to be the lack of availability and access to AAL technologies, the language associated with instructions to use the technology, the lack of perceived usefulness for dementia patients, uneasiness and resistance to use technologies due to intergenerational difference, family support, and cultural barriers.

The overall view from the study demonstrates that there are variations and differences to an extent in the barriers to adoption of AAL technologies among older Australians as compared to the barriers identified in previous studies. It gives an insight into what scenarios are favoured by the elderly for use of AAL applications and for what stages of life, or for what kind of activities they were likely to use the automated devices like robots. Secondarily, suggestions are also given on how the picture of the interface for AAL devices should look like.

This chapter describes the results drawn from analysis of two different data sources in detail. The first segment discusses the main highlights of each focus group. Secondly, the overall findings from the study, with statistics from the questionnaires have been presented. In the third section, the barriers have been explained followed by the discussion. Lastly, the concerns and preferences of the seniors towards AAL technologies have been discussed. The chapter has been concluded by the deliberations on the general attitude of elderly Australians towards the use of AAL technologies have been presented.

4.1 Focus Group Highlights:

Out of the two methods used for data collection, the most valuable information was drawn from the analysis of focus group data. Three focus groups were conducted in the Western Sydney Area in ARVs at three different locations between June 2017 and October 2017. The total number of participants that took part in the study was 25, out of which 22 respondents were involved in the focus group discussion. The information was drawn on the basis of the various

dimensions, including verbal and non-verbal expressions of the participants within the discussion.

The older people were very curious and interested in the research ever since the beginning of the session. Their valuable feedback was noted after watching the video on the introduction of AAL solutions and from the questions asked by the participants. Most of them were very intrigued by the idea of these technologies. However, a majority of the participants were also perplexed by the fact that they were never introduced to them in the past. Most of them were impressed by what these technologies could do in terms of providing them help with a range of activities. The main activities for which they were most likely to use AAL devices are lifestyle improvement, medicine reminders, mobility and help with daily chores. Some of them mentioned that they would not have left their home even if they could just afford to get help with daily chores like cleaning the house, gardening and more. A lot of them also mentioned that AAL technologies could be helpful for them to live independently by aiding to manage their chronic health conditions. A few female participants presented their interest in using assistive devices for personal hygiene as well. While most of the participants specified that technologies for connecting with the community would be helpful. Males were found more likely to use the technology for socialising and outdoor activities.

While they were impressed by the potential of AAL devices to help them, they were also frustrated by the fact that a lot of these technologies are not available to them. Some of the older people said that they would like to use these devices but they do not know how to access them even if they are available. In general, these participants were keen to know how they could find more about them. The video on AAL technologies displayed some examples of the available devices and their functionality and benefits for older people in improving their lifestyle. The most common devices the seniors were interested in was the medication dispensing device that can remind them of medicines and the robots that could help them with their daily life activities. Almost all participants showed their interest in knowing the ways to access them and the prices of these devices. However, most of them were not very clear about the functionality of smart home sensors and how other devices could help them with their health issues. A

considerable number of female participants raised their concerns about how these technologies would be able to help people with Dementia.

Following the introduction video and general discussion including the feedback questions, the focus group discussion was conducted. The three focus groups were conducted with a discussion on five main questions. These questions were built on the basis of thorough assimilation of the literature review done on types of existing AAL technologies, and on the barriers to their user-acceptance. The ability of participants to understand the questions was found to be satisfactory after watching the video and the general discussion. The participants were able to comprehend the questions based on reading them on the screen and through the researcher verbally explaining domains of each question. They were able to clarify the main idea of each question by asking the researchers in case they came across any doubts. The results from each focus group were diversified. But each of them had a unique and main topic of discussion that stood out in the discussion. Therefore, the summary and highlights from each focus group have been discussed in the following sections:

4.1.1 Focus Group I:

This focus group was conducted at Caddens Village, Kingswood, NSW, Australia, one of the Anglicare Residential Villages (ARV) in NSW. The number of participants that took part in the study was 8. All of them were recruited through the common recruitment method as described in the methodology section. Most of the participants in the first focus group belonged to the upper-socioeconomic background. After watching the video, most of them were impressed, and almost all of them mentioned that they were exposed to some kind of technology. In spite of that, 90% of the participants said they have never heard of the displayed AAL devices and described in the introduction videos and PowerPoint presentations. The common attitude was positive towards the usefulness of these devices. However, around 4 participants frequently questioned the functionality of each device for the patients with Alzheimer's. One of the respondents commented that "*Sure, the whistles and alarms will go up by the medication dispensing device but what about the person who can't remember or understand what that alarm is for, they will just look at it and won't know what to do with it*". A majority of them

indicated that they would appreciate more personalised technology according to their individual needs and concerns. They also uttered about the complexity of mobile applications and the difficulty in using touch-screens and latest devices in general. Five female participants mentioned that to be able to take advantage of the available devices, you need to learn how to use them, which is not easy. Most of the people were worried about the use of the cameras. However, one of the responders, aged 78, added that she would not mind cameras anywhere, provided that they were useful for health purposes. The participants particularly did not like the walking assist device for support. They found it funny looking and very obtrusive. However, they would appreciate the support from technology for daily activities. The major barrier that stood out in this focus group was the fear of human connection. A lot of them remarked that "*they would be terrified if they had to depend on technology for everything and do not get real people to talk to*". They mentioned that none of them would like to be stuck alone with the technology and they would instead live in communities like residential villages where they could meet other people and engage in activities that keep them active. In this particular focus group, the cost mattered to everyone and they conveyed the notion that they would not use these technologies unless the cost is affordable. None of them said they would compromise the cost over comfort. Many of them said that they would rather prefer to receive human care from aged care professionals, nursing home and family support. In the general feedback, the respondents stated that they were happy to use unobtrusive devices like buttons, sensors on the wall, floors, but, not the cameras. There seemed to be a clash among the choice of privacy and personal space over the comfort and other benefits from the use of these technologies. Overall, human touch stood out most among the other barriers addressed in this focus group. There seemed to be trust and reliability issues with the use of AAL devices. There was also strong resistance to uptake the technology merely because of the fact that the seniors didn't grow up with technology. One of the male respondents mentioned, "*technology didn't come naturally to us like current generation, so it is not easy for us to use it like kids*".

4.1.2 Focus Group II:

This focus group was conducted at the Ponds Village, The ponds, NSW, Australia- another Anglicare Residential Village (ARV) in NSW. The number of participants that took part in this focus group was 6. All of them were recruited through the common recruitment method as described in the methodology section. Similar to the first focus group, most of the participants in this focus group also belonged to the upper-socioeconomic background. After watching the video, most of them were impressed and four of them mentioned that they were not exposed to any kind of AAL technology apart from the alert button given to them at the ARV. Despite that, most of the participants said they had never heard of the AAL devices displayed and described in the introduction videos and PowerPoint presentations. Two of the seniors in the focus group were aware of the assistive devices available in Australia and knew that they have to contact agencies and it is not available directly to them. One of these two seniors mentioned he would like to get these technologies and even basic assistive devices from one place like 'My Aged Care', a service provided by the Australian government to access aged care services (HealthDirect Australia 2017). All participants mentioned that they would like government support to get access to these technologies. One of the participants said that "*it would be powerful to have technologies like these in nursing homes, to help nurses in moving forward*". Medication dispensing devices shown in the video was of particular interest. All participants would like to use it as soon as they can get access to it, provided it is affordable for them. Most of them were disappointed by the fact that these technologies are not advertised and available to them through government support. One of the female participants elaborated on the importance of human touch saying "*you need mixture, personal care is important. If you bring technologies, it should not affect the human contact*". Some of the activities they would like to use the technology for, as remarked by the participants, were personal grooming (mostly mentioned by female participants), activities of daily living (ADLs), and self-care. The participants from this focus group also suggested that they would like the technology to be more personalised and more automated. A female participant stated, "*they come down to a very personalised experience with some people not into email and some of them not even having phones, who are going to need a lot of help*." The discussion also concluded that the resistance to the use of technology

is a generation thing. A participant stated, "*the fact they don't use a computer doesn't mean they are not smart but that they are reluctant to use new technology*". There was a lot of discussion about the reliability of the technology in this focus group, as uttered by one of the participants "*My concern is if someone out there is looking after it, you might have to be careful of who is coming and hacking it*". The participants asked questions like: "*who else would be seeing this and how often*?" All participants laughed at the idea of having cameras in places like toilets and were concerned about being monitored by the camera at all. But one of the participants said, "*I could cope with cameras if it's an emergency*". The participants found that these technologies would be particularly helpful in improving their health issues and supporting them in increasing mobility and assist them with daily life activities. This is confirmed by the following comments from the participants: "*Every-day thing is important, more than the damn mobile", "these technologies would be really helpful for people who are self-caring", "Assistive technologies are probably gone keep us with the manageable health issues than putting in worse situation", "that sort of information about what's available for different issues could be really useful. For example, a lot of people could be living with arthritis here"*. The concern associated with the use of these technologies among people with Alzheimer's were presented here as well as stated by the statement from a participant "*the need for people with Alzheimer's would decrease because of degrading health*". The unawareness and the cost were the two major issues highlighted from this focus group discussion. Cost matters a lot to all the participants to be able to approve of these technologies. However, the overall response of the participants towards the usefulness of these technologies was found to be more positive as compared to the response from the previous focus group. The participants found these technologies to be specifically useful to improve their health and lifestyle while affirming that cost can't be overlooked, no matter what.

4.1.3 Focus Group III:

This focus group was conducted at St. Stephen's Village, Penrith, NSW, Australia, another ARV in NSW. The number of participants that took part in this study was 11. All of them were recruited through the common recruitment method as

described in the methodology section. The participants in this focus group belonged to middle class socioeconomic backgrounds and this particular group had higher academic qualifications as compared to those in previous groups. After watching the video on introduction of AAL technologies, all participants were impressed and almost all of them mentioned that they were exposed to some kind of technology. In spite of that, 90% of the participants said they had never heard of the AAL devices displayed and described in the introduction videos and PowerPoint presentations. One of the participants in this group affirmed that he was exposed to these technologies and mentioned using them when he had three major strokes in the past. The common attitude of the participants was observed to be 'curious' to know if these technologies are available. They were then frustrated that they could not use the devices shown in the videos because of unavailability and slow development in the field. The participants in this group mentioned their interest particularly in the Walking assist device as two of them were on wheelchairs while six of them have serious health issues that has restricted their mobility by a considerable amount. A few participants (10) showed their interest in the use of robots for daily life activities such as cleaning and gardening, and more. Similar to the previous groups, the majority of the interested respondents were curious to know about the price of these devices and when they could use them. Most of the participants insisted that these technologies should be available in Australia, particularly with the growth in number of older people in the country.

This group came out with a lot of concerns regarding the endorsement of AAL technologies. They mentioned that they find it very difficult to use technology, even when attempting to learn how to use various devices in general or any forms of technology, they come across different issues. One of these concerns was the complexity of language of instructions for using a device. Another was the poor customer service from the manufacturers and related departments. The participants stated they have an impression that the designers and the customer service agents use difficult language and assume that the seniors already know about it. This leads to disappointment among the participants, as they are unable to get optimum usage out of these technologies. The resistance to use this technology was quite strong among one of the participants, as he quoted "*The*

technology doesn't apply to me at all, I would be happy to have some lady or people come to the house and clean stuff". Two male participants and three female participants raised concerns about the misuse of their personal data gathered from the sensors and other monitoring devices. Some of the comments uttered by the participants were: "*It was in the news that someone's personal health information was stolen and misused", "if bank accounts can be hacked, then how can we rely on any technology*". They find it hard to overlook reliability issues of AAL solutions when it comes to monitoring them, even if the technology has potential to improve their health and lifestyle. The main factor that stood out in this group was the need of older people to improve their mobility. Other concerns were the reliability, the complexity of language used for user interface and limited support in digital literacy for seniors.

Each focus group discussion was followed by an additional discussion on participants' common perspectives on the AAL technologies. This information helped in gathering useful insights to understand and depict in detail, the general attitude of the seniors with the technology.

4.2 Questionnaires

The questionnaire was answered by a total of 25 participants, out of which 22 also participated in the focus group as well. The questionnaire consisted of 24 questions, out of which 18 participants answered all of them. All participants answered at least 21 questions. Thus, the response rate was quite high. Any doubts related to the questionnaire were answered by the researcher.

The analysis of written questionnaires also gave insights into the main barriers and the relation between them. The following conclusions accompanied by the figures and tables summarize the main results:

4.2.1 Language and User-Interface: Issues and Preferences

The results of the questionnaire showed that around 60% of the respondents are moderately comfortable in using the user-interface of currently existing technologies, while 40% still struggle to use these technologies in daily life.

However, when it comes to learning a new technology, a majority of them find it challenging. The questionnaire revealed that the language used for instructions on how to use these devices was found to be complex by the seniors, with 72% respondents responding as such.

The overall impression is that only 24% of the participants find it fairly easy to use common technologies in their daily life, while rest of the participants need some kind of assistance in using them. It is emphasized by the results from the questionnaire that ease of use is one of the major determining factors in the uptake of AAL technologies, as reported by 96% of respondents. Thus, it is important to acknowledge the need for digital literacy among seniors and to cater for it. This was supported by an additional comment provided by one of the participants: "*I am fairly comfortable with communication online but cannot imagine using these technology aids myself*".

The results from the questionnaire gave a concise estimate of preferences of the elderly in terms of training required for using AAL technologies. 67% of the respondents would prefer in-person assistance in using AAL devices, while others said they would prefer online step-by-step guide or manual trials to learn these technologies. However, 8% of the participants stated that they would be immediately annoyed if they find the technology hard to use. These results are demonstrated more clearly through the following figures (figure 4 and 5):

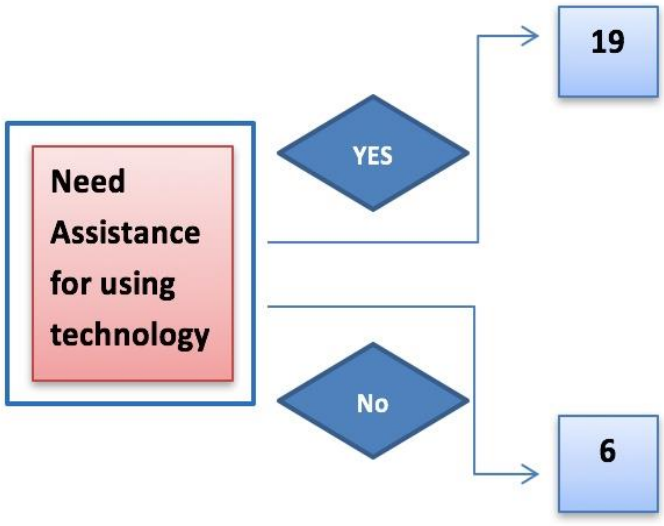

FIGURE 4: NUMBER OF OLDER PEOPLE REQUIRING ASSISTANCE FOR USING AAL TECHNOLOGY

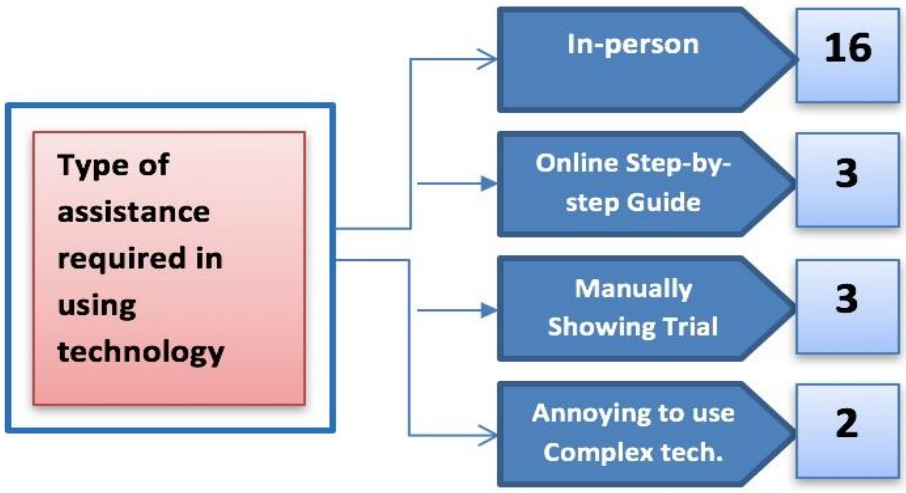

FIGURE 5: PREFERENCES FOR DIGITAL TRAINING

In addition to digital literacy, one of the major factors reported by participants in improving the adoption of these technologies is family support. Out of 21 respondents to this question, 81% mentioned that they think family support can improve the use of these technologies. This was supported by additional comments from 12 participants as shown below (Table 4.1):

Table 4.1: Participant's comments: Role of family support in using AAL technologies

QUESTION:	**DO YOU THINK THAT FAMILY SUPPORT CAN AFFECT THE USE OF THESE TECHNOLOGIES?**
NO **YES**	4 17
(IF YES, HOW) COMMENTS: (12 RESPONDENTS)	I. *"Grand Kids know a lot more than us about technology"* II. *"With advice, teaching from the children"*

	III.	*"By being able to assist and being in a position to assist"*
	IV.	*"I have a brother who teaches IT, however, I believe the error is the best medicine. Unfortunately, this needs self-confidence"*
	V.	*"By different opinions"*
	VI.	*"They probably know more than I do"*
	VII.	*"We are tech-savvy family, generally"*
	VIII.	*"My grandchildren can teach me"*
	IX.	*"The younger generation are great to help with technology"*
	X.	*"They are here from day to day"*
	XI.	*"My son already helps me with computer and online. I assume he would help me with assistive technology"*
	XII.	*"If they can't help what does one do"*

It is also important to notice that not all seniors feel comfortable in asking for help in using these devices. The collected data concludes that 29% participants would refuse to use the technology due to the fear of ridicule by asking assistance in using it. Thus, the results suggest that the deployment of the AAL solutions should be promoted with optimum support for training of elderly people in using them. Since the family members, the aged care institutions are also involved in using these applications, they should also be included in such training.

4.2.2 Daily-life support: Needs and Preferences

The importance of human interaction was highlighted in all the focus group discussions and interviews. The results from the questionnaire reveal more links to the importance of human connection being a prominent barrier restricting the adoption of AAL applications. Out of the total respondents (*n*=22), 14 seniors mentioned that they would not prefer to take help from technology over personal carer or family member, if given an option. Out of 14 people who would not be happy to use technology for assistance in daily life activities suggested that they would appreciate the family support over technology or professional carers for daily support. This data was very visibly connected to the privacy issues of the older people. People who said yes to the use of technology over family or personal carers also said they were not very comfortable in taking help for personal care at aged care places or nursing homes. The amount of care the seniors would like to receive from technology or the nursing homes depends on the context of their need. 59% of the participants associate the use of technology for their ongoing and past health concerns to varying extents. Thus, seniors have very specific needs, and preferences while using the AAL technologies. This is justified by the data as shown in the following figures (figure 6 and 7):

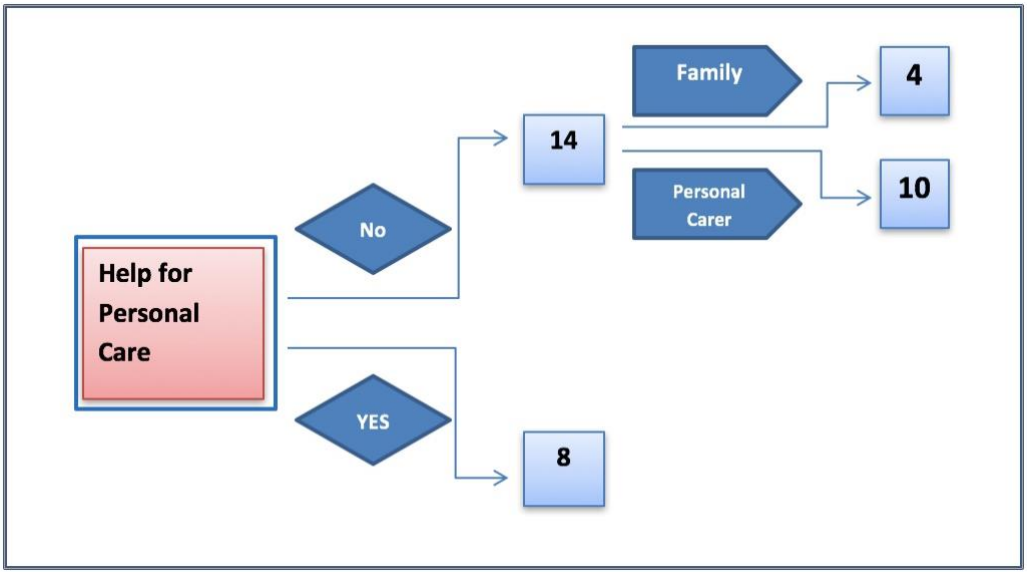

FIGURE 6: DAILY-LIFE SUPPORT - USERS PREFERENCES

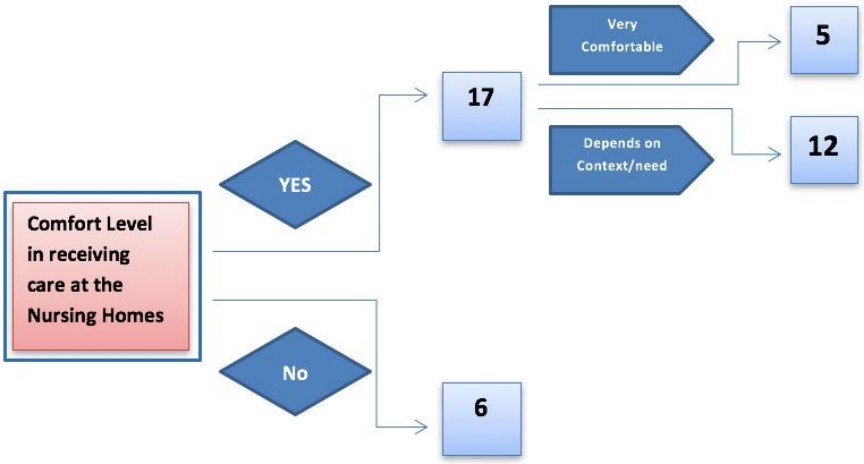

FIGURE 7: DAILY-LIFE SUPPORT - USERS PREFERENCES II

4.2.3 Privacy vs Comfort:

Privacy is important to the elderly Australians. However, with the decline in the overall functioning of their body, it is more important for them to maintain their overall health by taking optimum support from different sources. The results suggested that 67% of the participants would prefer comfort to privacy while considering the use of AAL solutions.

This percentage was also accompanied by additional comments from 4 participants, 2 of them stating that it would depend on the type of technology and their needs. Thus, the uptake of these technologies could be higher if perceived usefulness is increased for the users.

4.2.4 Security and Reliability:

The state of seniors feeling secure from the use of assistive technologies depends on the purpose and context for which the device is used. The results suggest that 78% of the total respondents link the security to the purpose and context for which the technology is used for monitoring them.

More of those studied (56%) who felt secure being monitored or recorded, associated the use of technology with medical purposes associated with their health concerns. Thus, the results from the questionnaire advocate that there are

high chances of elderly people using assistive technologies for health purposes in addition to using them for ADLs.

4.2.5 Cost and Perceived Usefulness:

Cost is found to be one of the main factors affecting the adoption of AAL technologies among the older Australians as supported by the information drawn from the questionnaire. 87% respondents said the cost matters to them, out of which 70% said that the degree to which cost matters depends on how useful they find technology to cater to their specific needs. Thus, there is a demonstrated link between the cost and the usefulness of the technology to the older adults as demonstrated by the data from the questionnaire (refer Figure 10).

4.3 Major Barriers:

The study identified few barriers, concerns and preferences for older Australians in the adoption of AAL technologies. These are summarized under the following categories:

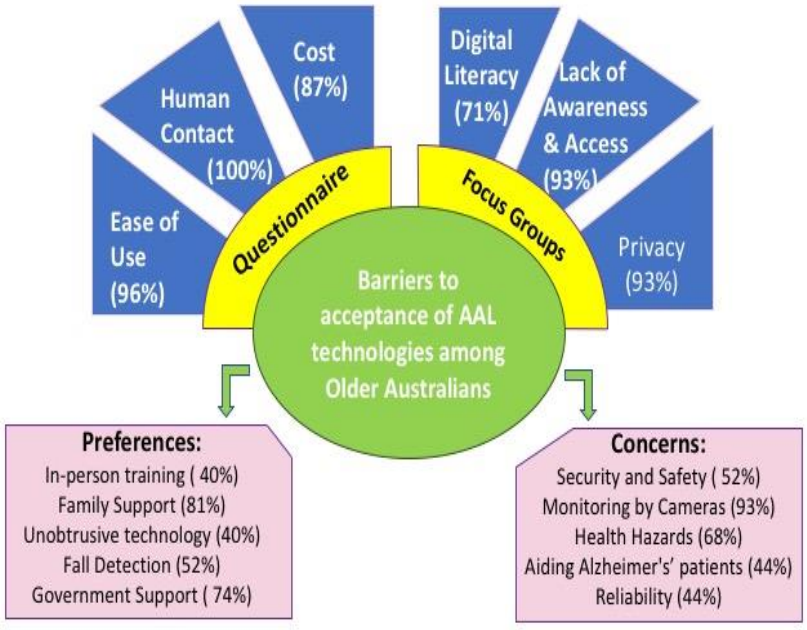

FIGURE 8: MAJOR BARRIERS IN THE ADOPTION OF AAL TECHNOLOGIES

4.3.1 Human Connection:

The fear of losing human interaction was reported as the main barrier with 100% respondents. The older people are worried about technology replacing human care. In fact, they prefer family or professional aged-care over technology for the medical purpose with 71% respondents agreeing to it. The sense of foreboding around this was extended to the point that one of the participants mentioned that the technologies do not apply to him at all in any sphere of his life despite being impressed with the potential of AAL technology use. The importance of places like residential care was discussed by a lot of participants in the focus group. They mentioned that they would prefer community connection and assistance rather than the help from technology if there was a choice. The apprehension for losing human contact revolves around basic human nature and some common concerns associated with ageing (Cacioppo & Patrick 2012).

Participant x: *"I am concerned about technology replacing human care."*

Participant y*: "Just the human touch, you need."*

Participant z: *"Nothing will replace the human carers who can give you the medicines."*

Participant u: "*I don't think you can replace human care."*

Participant v: *"Need someone to talk to, from care point of view."*

Participant y: *"Human care is important."*

Participant a: "*you need personal contact as well. One on one talking, laughing and singing. You know all these kind of activities*."

Participant b: "*If you bring the technologies, it should not affect the human role in our lives*."

Participant k: "*it would be nice to have a lady to clean the house rather than technology that you can't even talk with*"

4.3.2 Lack of Awareness and Access:

93% participants reported that the lack of awareness would hinder the adoption of AAL technologies for them. Most of them were not aware of these technologies before the session. Those who were aware knew about technologies like alert button and sensors. The participants shook their head in amazement after watching the video on the AAL technologies and most of them questioned why they have never been introduced to the assistive technologies before the session. They indulged in discussion presenting the need for marketing of these technologies. More than 80% of the older adults agreed on the notion that, to begin with, they have to know about these devices to even try to use them or even be interested in them.

Some of the participants presented frustration from not getting to use these technologies in spite of them having the hope that they can get help from these devices with activities like health issues, increased mobility and household activities. They were curious to know how they could access these technologies. Thus, one of the major barriers restricting the deployment of these technologies is the lack of availability and accessibility to these technologies.

Participant u: *"That sort of information about what's available for different issues could be really useful. For example, a lot of people could be living with arthritis and they could access help from these technologies if they know what's out there".*

Participant j: *"But are these technologies going to be available any soon, nothing is available here"*

4.3.3 Ease of Use:

Another major barrier was found to be the difficulty seniors face in using the technology with 93% respondents. They find the technology very complex and hard to understand.

Participant x: *"We had an alert button at one of the resident's places I didn't know how to help her. We had to call other people to know how to use it. We couldn't get into the house, had to call the police. We did learn where the key was. We got to know for the next time".*

4.3.4 Digital Literacy:

The lack of training in using these technologies was reported to be a barrier by 71% respondents. In fact, 71% participants find it hard to understand the language associated with the technology and more than half of them would prefer to get personal training in using AAL devices.

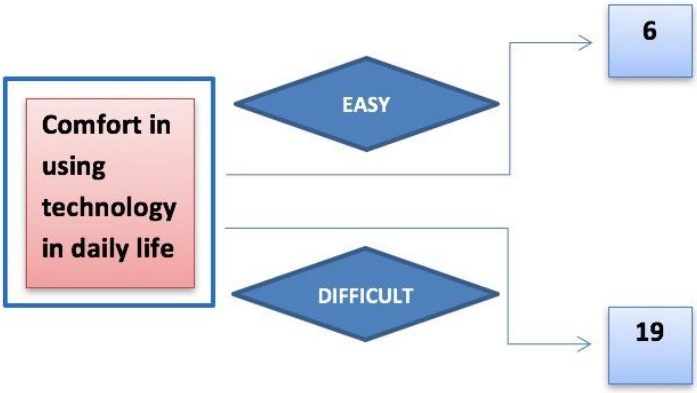

FIGURE 9: USERS' COMFORT LEVEL IN USING TECHNOLOGY IN DAILY-LIFE

4.3.5 Cost:

The cost was found to be a major factor restricting the use of AAL technologies among the elderly, with 79% respondents. Participants have regard for the government support in being able to access these technologies.

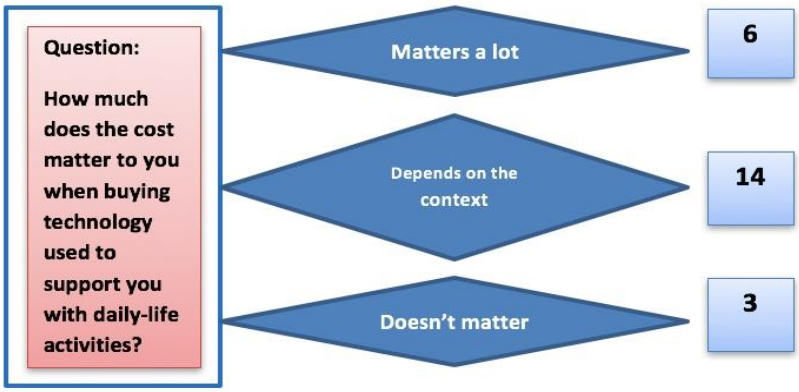

FIGURE 10: COST AND PERCEIVED USEFULNESS OF THE AAL TECHNOLOGIES

There is an established connection between the cost and its perceived usefulness with 69% participants agreeing to pay for the technology if they find it useful.

Participant e: *"I am horrified by the cost."*

Participant c: *"You can't get these technologies because it would take all your savings away."*

Participant b: *"If the government is going subside it in some way and it's going to bring down their price to look after someone, it has to work both ways. Depends on the benefit to somebody."*

Participant d: *"This really comes down to what somebody needs."*

Participant e: *"I will save to buy a good program."*

Additional factors that affect the use of these technologies were reported through the open discussion in the focus groups. 46% of the participants desire the technology to be invisible and unobtrusive while 40% questioned their reliability.

4.4 Concerns, Attitudes and Preferences:

In addition to the barriers that restrict the adoption, the elderly also presented some concerns with the use of AAL technologies. Most of the participants (93%) mentioned that they had concerns while being monitored by the cameras while one of the participants stated that she would not mind being monitored if it was concerned with her health and safety. On the other hand, 93% of the participants reported that were fine being monitored by sensors. Furthermore, a few of them prefers to get help from AAL applications in case of fall events or other emergencies. Some of the respondents (60%) said that they are worried about health hazards caused by the use of these technologies. There was noticeable interest among participants to know the role of AAL technologies in helping the people with health issues like Alzheimer's. Even though we didn't include the older people with dementia in the study due to ethics constraints, the participants presented their bearing on the equal use or specialised adjustments in the AAL solutions for the dementia patients. Participants were intrigued to know how the devices like Medication Dispenser will help the dementia patients and cater to their power of retention and support them for medication adherence. Some of the

suggestions by the participants for their acquaintances with dementia patients were the development of automated devices without necessarily stigmatising them. Other important recommendations were keeping the options in the user interface to the minimum to avoid cognitive overload and minimise physical effort in using it. Some of the comments from the participants are as below:

"What If these alarms and all go on, but the person with Alzheimer's can't understand what the reminder is about"

"I am worried about these technologies are going to help a person with dementia"

"Someone with memory issues will not remember to turn on the device or operate a device in case of power failure"

The participants expressed their concerns about the reliability of the technology. Issues like power or system failure and automatic functions that require vigilance were raised by the older people. Some of them are reluctant to use technology because of their comfort zone. The intergenerational gap was also reported to be a major issue that stops them from using the technologies in general, which is equally applicable to the use AAL technologies.

Participant u: "*We didn't grow with that, so technology didn't come naturally to us."*

Participant t: *"If I just like things old-school style, doesn't mean someone is not smart."*

However, they are happy to use these technologies for daily-life activities like cleaning, gardening, personal grooming and other household activities. Family support is considered to be helpful to the participants (71%) in making the technology easier for them to use. Connection with the community and engagement in activities that make them active and healthy are important for the seniors. Overall, older people were ready to accept these technologies if the barriers could be managed. They also indicated that they would like to access AAL technologies through a common place like 'My Aged Care', a service provided by the Australian government to access aged care services (Healthdirect Australia 2017). They want these technologies to be integrated with current facilities rather than making effort to access these technologies separately. The

participants found the video on introduction to these technologies very informative and were excited to see and get support from them in the future for certain activities.

Interestingly, the attitude and concerns of older people were shown to be varying depending on the location of where the older people spend most of their time. The seniors who spent most of their time near the urban areas were more comfortable with the idea of using AAL devices to improve their lifestyle. However, people who lived in regional areas were more reluctant to get support from them. Comparatively, they preferred old-school style to improve their lifestyle.

5. CONCLUSION AND FUTURE WORK

5.1 Conclusion and Discussion

This thesis has used mixed methods approach to investigate the factors that restrict the adoption of AAL applications among elderly Australians. The participants were 65 years old and over. Focus groups and written questionnaires were used for this research.

Ambient Assisted Living technologies have significant capabilities in providing the aid to aged care services and aged care professionals, therefore, reducing economic and social implications of an ageing population. This work has been intended to aid the human-centred design process, for the successful development of AAL solutions. Although the results from this study were found to be in alignment with the results from previous studies, there were some prominent differences in the perception of these technologies among older Australians.

The study has provided a peek into the current use of AAL applications by the seniors, including the kind of technologies used and the purpose for using them. The main factors that hinder the use of AAL solutions among the elderly in Australia were drawn from the study. The results demonstrate that 60% of the participants have internet at their homes and 93% had concerns while being monitored by a camera. The perceived usefulness of AAL devices was found to be connected to some factors such as cost and security. The participants were willing to pay for the devices if they found them useful. Security was also connected with the use of the AAL applications for medical purposes. Digital literacy and the ease of use were the important factors in the adoption of AAL solutions, with 71% and 93% respondents respectively.

The findings show that participants have some concerns regarding health hazards, reliability (system failure), obtrusiveness of devices and privacy with 60%, 40%, 46% and 33% respectively. However, it was noted that 67% participants were ready to compromise privacy for comfort and increased mobility. Older cohort (those over 80) were more likely to use AAL devices for improved physical and emotional independence, specifically, for increased mobility. While majority of the participants preferred to use automated AAL applications like robots for daily chores, 100% participants also reported that they do not want robots to replace human-care and interactions. They were more

likely to use AAL solutions that assist them to become more active, socially connected. They also prefer applications that provide access to online educational training.

The results demonstrate that factors such as digital training, family support, government support, easy to use interface, increased privacy and security, improved accessibility through My Aged Care (Healthdirect Australia 2017), can improve the uptake of AAL devices among them. The participants showed profound interest in medication dispensing device and other cognitive orthotics, specifically, for wellbeing of their acquaintances suffering from dementia. Additionally, factors such as intergenerational difference and fear of ridicule (from seeking assistance to use the applications) were found to act as barriers. This concluded the importance of designing flexible user-interface adaptable to the specific need of dementia patients, without stigmatising this group. One of the main inferences drawn from the study was the importance of involving different stakeholders, in the design of AAL devices. It is expected to inspire the designers to accelerate the user-focused design process, by using the knowledge drawn from this work. This is possible through accommodating decision drivers of the primary users of AAL technologies.

Thus, this project will work towards improving the utilization of this technology. This is an ongoing project with an aim to conduct further study while targeting a total of 40 participants and include individual interviews as an additional methodology. It is aimed to expand the study in future while incorporating the AAL technologies so that the participants (elderly Australians) can understand their benefits more clearly.

5.2 Limitations and Future Work

The project demonstrates significant information on the major restraints faced by the elderly Australians in using AAL technologies. It analyzed both, the

inflexibility, and the readiness of the current AAL applications, towards behavioural aspects of the seniors. However, the project excludes the analysis of the elderly's attitudes towards specific AAL devices. Instead it aims to understand the overall barriers in acceptance of AAL technologies. This study cannot be conducted alone through quantitative methods because of nature of the research. Thus, additional methods like individual interviews should be incorporated in the future to get deeper understanding of these barriers. Variations are possible over time, and reactions can change according to the local situations and events. Through the proposed methodology, the project considered contingencies involved in studying the subjective phenomenon. The most prominent limitation of the project was the challenges faced during data acquisition. The participants belong to a specific category of the population where it was be crucial to consider their physical, mental and psychosocial status before undertaking any kind of study. The size of the questionnaire might have to be reformulated in the future, depending on the amount of time and concentration the elderly is willing or capable of devoting to the interviews and questionnaires. The quality and size of data could vary according to how much the interviews are affected by cultural, intellectual, linguistic, health and wellness factors. Another major limitation of the project is the availability of technology. Depending on the kind of technologies available for conducting the research, the standard of data collection is prone to inaccuracies. The availability of more resources could lead to access to more places for conducting the research. However, the project aimed to target the data collection demographically rather than geographically. The designed questionnaire may need to be altered according to the future circumstances. To draw more accurate results, the data set could, however, be larger, if the timeline was longer. It is relative to mention here that the high similarity index in this thesis is from my own papers. The main limitations of the project are reiterated as follows:

- Number of participants
- Limited Locations
- Fewer resources to help participants comprehend the functionality of AAL devices

- The pilot study – limited time
- Study unable to address people from varying socio-economic backgrounds, living circumstances, life experiences and diversified cultural backgrounds
- Understanding basic needs of older people through a comprehensive study is important

The literature review reveals very less amount of studies regarding AAL technologies in Australia, which suggests the need for researchers to conduct more detailed studies in the field. Future work should include larger samples to draw more details and also understand the benefits of AAL solutions using different approaches. For example, studies could utilize participatory designs, focus groups with secondary and tertiary stakeholders to gain more knowledge about the perceptions and outlook. Consequently, this will uncover the expected restrictions to the deployment of AAL applications.

5.2 Statement on Potential Impact:

The growing population of older people worldwide and within Australia is, in turn, accelerating the demand for aged care services (Calvaresi et al. 2016). The responsibility of care affects not only the carers but also the family members and relatives of the elderly, the nursing homes, the government and the wider community across the board. Age-related diseases like Alzheimer's' and Parkinson's disorder has increased over the past decade. In fact, Dementia was declared as the ninth national health priority in 2012 by the Australian government. It was also the second dominant cause of disability among people aged 65 and over (Australian Institute of Health and Welfare 2012). The financial burden on the Australian Government for providing aged care services is sharply augmented by the change in demographics of Australia (Productivity Commission-Australian Government, 2014). According to the Australian Institute of Health and Welfare (AIHW), the cost of aged care will increase from a level of 8.4% of GDP in 1996 to 14.5% of GDP by 2030 (Planning et al. 1996). Ambient Assisted Living technologies have significant capability in providing the aid to aged care services, health care professionals and informal carers. Improvement

and deployment of AAL technologies are also an answer to help disabled people in living independently.

Thus, the current project has worked towards improving more widespread utilization of this technology. Consequently, revealing the evidences to help government in the upgrade of current policies to answer the demand for increased aged care services. The implications of the project are broad. However, the main audience of the project is the designers in the telehealth industry. The results from the study will help and inspire them in building technologies that will overcome these barriers and aid in the adoption of these technologies on a larger scale. The study will contribute significant knowledge within the user-acceptance domain of the field and will encourage the researchers to work towards deployment of these technologies in the real world. Researchers within the field would be able to utilise the results in conducting research towards developing a common platform for sharing these technologies.

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APPENDIX A: HUMAN ETHICS APPROVAL

Locked Bag 1797
Penrith NSW 2751 Australia
Research Engagement, Development and Innovation (REDI)

WESTERN SYDNEY UNIVERSITY

REDI Reference: H12251
Risk Rating: Low 1 - LNR

HUMAN RESEARCH ETHICS COMMITTEE

8 June 2017

Doctor Upul Gunawardana
School of Computing, Engineering and Mathematics

Dear Upul,

I wish to formally advise you that the Human Research Ethics Committee has approved your research proposal H12251 "Ambient Assisted Living Technologies among older Australians: A study of barriers in user experience", until 8 October 2017 with the provision of a progress report annually if over 12 months and a final report on completion.

In providing this approval the HREC determined that the proposal meets the requirements of the National Statement on Ethical Conduct in Human Research.

This protocol covers the following researchers:
Upul Gunawardana, Chetna Maan

Conditions of Approval

1. A progress report will be due annually on the anniversary of the approval date.

2. A final report will be due at the expiration of the approval period.

3. Any amendments to the project must be approved by the Human Research Ethics Committee prior to being implemented. Amendments must be requested using the HREC Amendment Request Form:
https://www.westernsydney.edu.au/__data/assets/word_doc/0012/1096995/FORM_Amendment_Request.docx

4. Any serious or unexpected adverse events on participants must be reported to the Human Research Ethics Committee via the Human Ethics Officer as a matter of priority.

5. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the Committee as a matter of priority

6. Consent forms are to be retained within the archives of the School or Research Institute and made available to the Committee upon request.

7. Project specific conditions:
There are no specific conditions applicable.

Please quote the registration number and title as indicated above in the subject line on all future correspondence related to this project. All correspondence should be sent to the e-mail address humanethics@westernsydney.edu.au as this e-mail address is closely monitored.

Yours sincerely

Professor Elizabeth Deane
Presiding Member,
Western Sydney University Human Research Ethics Committee

Locked Bag 1797
Penrith NSW 2751 Australia
Research Engagement, Development and Innovation (REDI)

WESTERN SYDNEY UNIVERSITY

REDI Reference: H12251
Expiry Date: 1 November 2017

HUMAN RESEARCH ETHICS COMMITTEE

26 September 2017

Doctor Upul Gunawardana
School of Computing, Engineering and Mathematics

Dear Upul,

RE: Amendment Request to H12251

I wish to formally advise you that the Human Research Ethics Committee has approved your request to amend your approved research protocol H12251 "Ambient Assisted Living Technologies among older Australians: A study of barriers in user experience".

The approved amendments are:

Add interview questions

Add new participant group - senior citizens living in different settings and different areas including rural areas.

Add new sites: Anglicare (ARV) Villages - Caddens, The Ponds, Lemon Grove, St Stephens, Public spaces in NSW

Extend study duration. New expiry date 01/11/2017

Project specific approval conditions:
There are no specific conditions applicable.

Please quote the registration number and title as indicated above in the subject line on all future correspondence related to this project. All correspondence should be sent to the e-mail address humanethics@westernsydney.edu.au as this e-mail address is closely monitored.

Regards

Professor Elizabeth Deane

Presiding Member,
Human Researcher Ethics Committee
Western Sydney University

APPENDIX B: FOCUS GROUP DOCUMENTS

Recruitment Flyer

Focus Group Session for a Research Study

Are you a senior citizen aged 65 or over to be able to consent independently?
Would you like to know how assistive technologies can improve your lifestyle?
Would you like to give your opinions about your experience with technology?

If so please come along and join Researchers from Western Sydney University for the morning tea and a focus group session.

The study involves a time commitment of 60 minutes for focus group and answering a written questionnaire.

When: Friday, 15th September 2017
Where: St. Stephens Village – The Hall
Time: 11am – 12:30pm (With the tea break)

To know more details about the study, please collect information sheet from reception and RSVP by Wednesday 4th October 2017 by adding your name to the sign-up sheet at the Anglicare St. Stephens Village Office.

Hope to see you there- Chetna

In case of any questions or find out more information about this study, please contact Chetna Maan or Dr. Upul at: #####
Phone: 02-96854608 **#**
Email: 18305845@student.westernsydney.edu.au

Study Title: Ambient Assisted Living Technologies (AAL) Among Older Australians: A Study of Barriers in User Experience

Principal Investigator: Chetna Maan **#**
Project Supervisor: Dr. Upul Gunawardana

WESTERN SYDNEY UNIVERSITY

#

Participation Information Sheet

WESTERN SYDNEY
UNIVERSITY

Participant Information Sheet – General (Extended)

Project Title: *Ambient Assisted Living Technologies Among Older Australians: A Study of Barriers in User Experience*

Project Summary:

The demand for older Australians to live independently at home has increased more than ever in the past. One of the things done to address this demand is the development of Ambient Assisted Living (AAL) technologies. However, the use of these technologies among the senior Australians remains a big concern.

The research is aimed at studying the barriers in user experience for improving the acceptance of AAL technologies among its end-users (the older Australians).

You are invited to participate in the research study being conducted by Chetna Maan, Master of Research Student, under the Supervision of Dr. Upul Gunawardana, Senior Lecturer with School of Computing, Engineering and Mathematics at Western Sydney University.

How is the study being paid for?

The project will be funded by School of Computing, Engineering and Mathematics, Western Sydney University within limit of $2000 and any additional costs related to the project will be managed by the researcher.

What will I be asked to do?

You will be asked to participate in a focus group and to answer a short questionnaire.

How much of my time will I need to give?

60 Minutes.

What benefits will I, and/or the broader community, receive for participating?

The research will help you get familiar with the support available from technology for living independently at later stages of your life. You will be able to understand the benefits of the AAL technology and it will prompt you to think about accessing the government support for using these technologies to make your lives easier.

There is a future possibility of changes in government policies for older people which will directly benefit you and the wider community, which includes medical professionals, carers and the family and friends of the senior citizens. Consequently, the study could potentially benefit the overall economy of the country.

You will be provided morning tea for your valuable time. You will be informed about the results of the research through email or by post (optional).

Consent Form

Consent Form – General (Extended)

Project Title: *Ambient Assisted Living Technologies Among Older Australians: A Study of Barriers in User Experience*

I hereby consent to participate in the above named research project.

I acknowledge that:

- I have read the participant information sheet (or where appropriate, have had it read to me) and have been given the opportunity to discuss the information and my involvement in the project with the researcher/s
- The procedures required for the project and the time involved have been explained to me, and any questions I have about the project have been answered to my satisfaction.

I consent to:

[Insert tick box option for each specific activity e.g.

☐ *Participating in a focus group*

☐ *Having my information audio recorded*

☐ *Filling out a short written questionnaire*

I consent for my data and information provided to be used in this project and other related projects for an extended period of time.

I understand that my involvement is confidential and that the information gained during the study may be published and stored for other research use but no information about me will be used in any way that reveals my identity.

I understand that I can withdraw from the study at any time without affecting my relationship with the researcher/s, and any organisations involved, now or in the future.

Do you want a copy of the results from the research study? (Optional)

No

Yes - Please provide your contact details -

Phone no. and/or Email:

!

Signed:!

Name:!

Date:!

!

Return!address:!School!of!Computing,!Engineering!and!Mathematics!
Western!Sydney!University!
Locked!Bay!1797!
Penrith,!NSW!2751!
Australia*!*

!

This!study!has!been!approved!by!the!Human!Research!Ethics!Committee!at!Western!Sydney!University.!The!ethics!reference!number!is:!H12251*!*

!

What!if!I!have!a!complaint?!

If!you!have!any!complaints!or!reservations!about!the!ethical!conduct!of!this!research,!you!may!contact!the!Ethics!Committee!through!Research!Engagement,!Development!and!Innovation!(REDI)!!on!Tel!+61!2!4736!0229!or!email!humanethics@westernsydney.edu.au.!

Any!issues!you!raise!will!be!treated!in!confidence!and!investigated!fully,!and!you!will!be!informed!of!the!outcome.!!

!

!

!

!

Written Questionnaire

ASSISTED LIVING TECHNOLOGIES AMONG OLDER AUSTRALIANS: QUESTIONNAIRE

!

Please encircle the option most relevant for you

!

Q1. Are you aged 65 years or above?

- Yes!
- No!

!

Q2. Your Age (optional): ☐

!

!

Q3. Gender:!!!!!!Female/!Male!

!

Q4. Is English your first language?

- Yes!
- No!

!

Q5. How do you find the language associated with the technology use?

- Easy!
- Difficult!
- Fairly!easy!
- Very!Difficult!

!

Q6. Do you struggle with the complexity of language used for instructions on how to use technology?

- Yes!
- No!

!

Q7. What is your highest educational qualification?

- School!leaver!
- Senior!School!Certificate!
- Vocational!Graduate!diploma/certificate/!Advanced!Degree/!Certificate!IV,!III,!II,!I!
- Bachelor!Degree!
- Graduate!Diploma/Certificate/!Doctoral!Degree/!Master!Degree!
- Other:!_____!

!

Q8. How comfortable do you find it to use the technology in daily-life?

- VeryJeasy!
- Easy!
- Need!little!assistance!
- Needs!assistance/!Don't!appreciate!the!complexity!of!technology!

!

Q9. What kind of assistance would you prefer to have from using technology?

- InJperson!
- Online!stepJbyJstep!guide!
- Manually!showing!the!trial!
- It's!annoying!to!use!any!technology!
- !

!

!

Q10.'What'kind'of'control'would'you'prefer'while'using'devices?!

!

A)! Automatic!
B)! Manual!
C)! Customized!

!

Q11.'Would'you'like'to'use'technology'if'it'was'easy'to'use?'

- Yes!!
- No!
- Depends!!!!!!!!!!!!!!!!!!***Comments:&***_____!

!

Q12.'What'would'you'prefer'most'for'care'at'home'or'for'support'in'daily'life'activities?' How'comfortable'do'you'find'yourself'to'get'help'for'personal'care'from' family/friends/relatives?'

!

- Personal!carer!
- Help!from!technology!
- Family/!Friends/!Relatives!

!

Q13.'What'would'you'prefer'while'using'a'technology?'

- Privacy!
- Comfort!

!

Any'additional'comments?!(optional):!

!

!
!
!
!
!
!

Q14.'How'secure'do'you'feel'being'monitored'or'recorded'for'medical'purposes?'

- Happy!to!be!monitored!all!the!time!
- Not!at!all!/!Serious!privacy!issues!
- Depends!on!what!technology!is!used/what!is!monitored!

!

Q15.'How'reliable'do'you'think'are'these'technologies?'

- Not!reliable!at!all!
- Somewhat!reliable!
- Reliable!

!

Q16.'How'comfortable'do'you'find'yourself'to'get'help'for'personal'care'at'aged'care' places/nursing'homes?'

!

- Not!at!all!
- Depends!on!the!context!and!need!!
- Very!comfortable!

!

!

Q17.'What'is'your'cultural'background/ethnicity,'please'write'down'below:'

!

_____!

!

!

Q18.'Do'you'think'family'support'can'affect'the'use'of'these'technologies?'

!

- Yes!
- No!

!

If!yes,!how?!!(Optional)!

!

Q19.'Do'you'link'the'need'for'use'of'Assistive'technology'with'your'current'health' concerns'or'serious'health'issues'suffered'in'the'past?'

A)! Yes!
B)! No!
C)! May!be!
D)! Not!applicable!

!

Additional!details,!if!any!(optional):!

!

Q20.'Do'you'associate'the'rejection'of'the'technology'with'the'fear'of'ridicule'from'asking' assistance'in'using'it?'

A)! Yes!
B)! No!
C)! May!be!
D)! Not!applicable!!!

- ***Comments:&***_____!

!

!

'

Q21.'Will'you'be'concerned'if'the'technology'is'too'visible?'

'

A)! Yes!
B)! No!
C)! May!be!
D)! Don't!care/!doesn't!matter!

!

!

!

!

Q22.'How'much'does'the'cost'matter'to'you'when'buying'technology'used'to'support'you'with'daily'life'activities?'

!

- Not!at!all!
- Depends!on!the!purpose!and!requirement!of!technology!!
- Matters!a!lot!

!

!

Q23.'Are'you'concerned'about'possibility'of'health'hazards/'side'effects'(such'as'electromagnetic'radiations'etc.)'caused'by'use'of'Assistive'technologies?'

!

- Yes!
- No!
- Depends!on!the!purpose!and!requirement!of!technology!!

!

Q24.'So'far'in'life,'where'have'you'lived'most'of'your'time?'

!

Suburb/city/!town:!_____!
State:!_____!
Country:!_____!

!

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!!!!!!!

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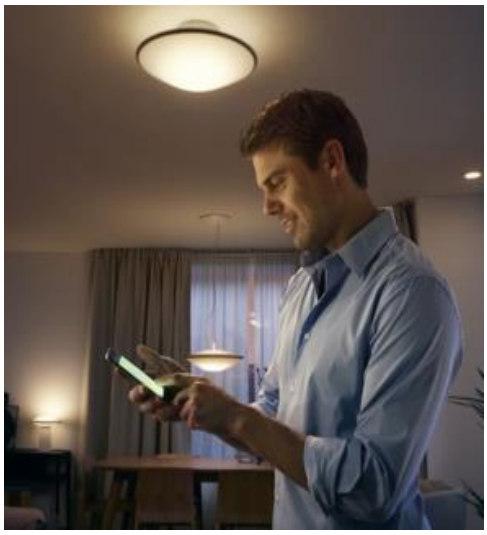
APPENDIX C: IMAGES

Images used for the Introductory Session and Focus Group presentation/videos:

Source: Natasha Lomas, 2017, *Google's Amazon Echo competitor and WIFI router*, [Image], Retrieved from: https://techcrunch.com/2017/03/28/googles-amazon-echo-competitor-and-wifi-router-launching-in-uk-on-april-6/

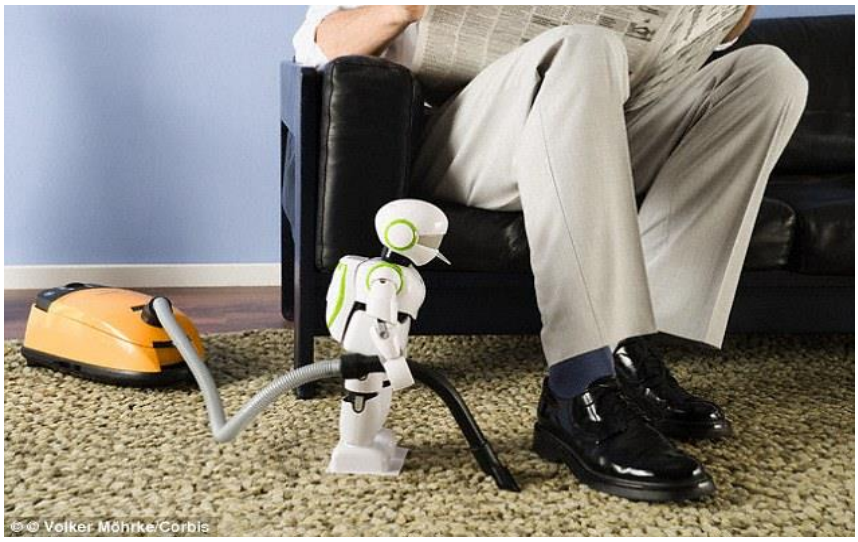
Source: GDC Telecom SRL, 2017, *FIBARO System*, [Image], Retrieved from: http://gdctelecom.ro/en/home-automation/fibaro-system



Source: Independent Living Centres Australia, 2011, *Philips Hue Connected LED light*, [Image], Retrieved from: http://ilcaustralia.org.au/products/19099?search_tree=1077

Koninklijke Philips N.V., 2016, *Automated Medication Dispensing Service*, [Image], Retrieved from: https://www.lifeline.philips.com/pill-dispenser/health-mdp.html

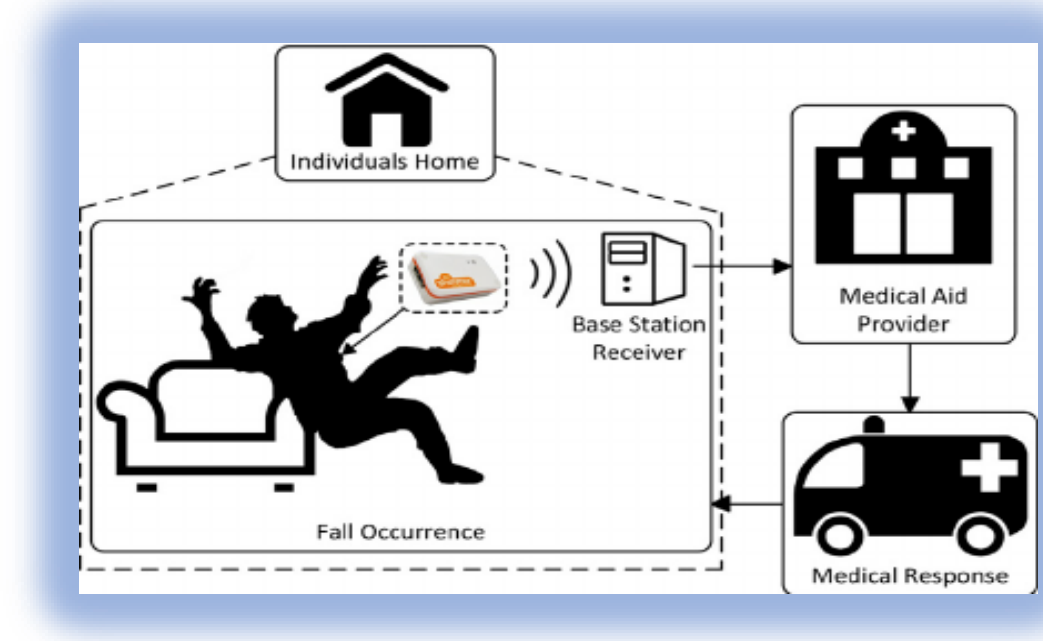
Medgadget, LLC. 2004-2017, *HONDA Robotic Walking Assist Device*, [Image], Retrieved from:https://www.medgadget.com/2008/11/honda_makes_public_new_robotic_walking_assist_device.html



From weeding the garden to picking up socks from the floor, robots may soon be able to do all of your household chores. Researchers are now working to design fairy-godmother drones to ease these burdens for senior citizens, and they say it's closer to becoming reality than you may think
Read more: http://www.dailymail.co.uk/sciencetech/article-3346356/Will-elderly-soon-DRONES-look-1-5m-project-create-Bibbidi-Bobbidi-Bots-help-home.html#ixzz51nKsnleL

Source: Cheyenne MacDonald, 2015, *Will the elderly soon have DRONES to look after them? $1.5m project will create 'Bibbidi Bobbidi Bots' to help around the home,* [Image], Retrieved from: http://www.dailymail.co.uk/sciencetech/article-3346356/Will-elderly-soon-DRONES-look-1-5m-project-create-Bibbidi-Bobbidi-Bots-help-home.html

Source: Delen, 2013, Ambient Assisted Living 4, [Image], Retrieved from: https://afterhourscoding.wordpress.com/2013/02/27/ambient-assisted-living-4-all/

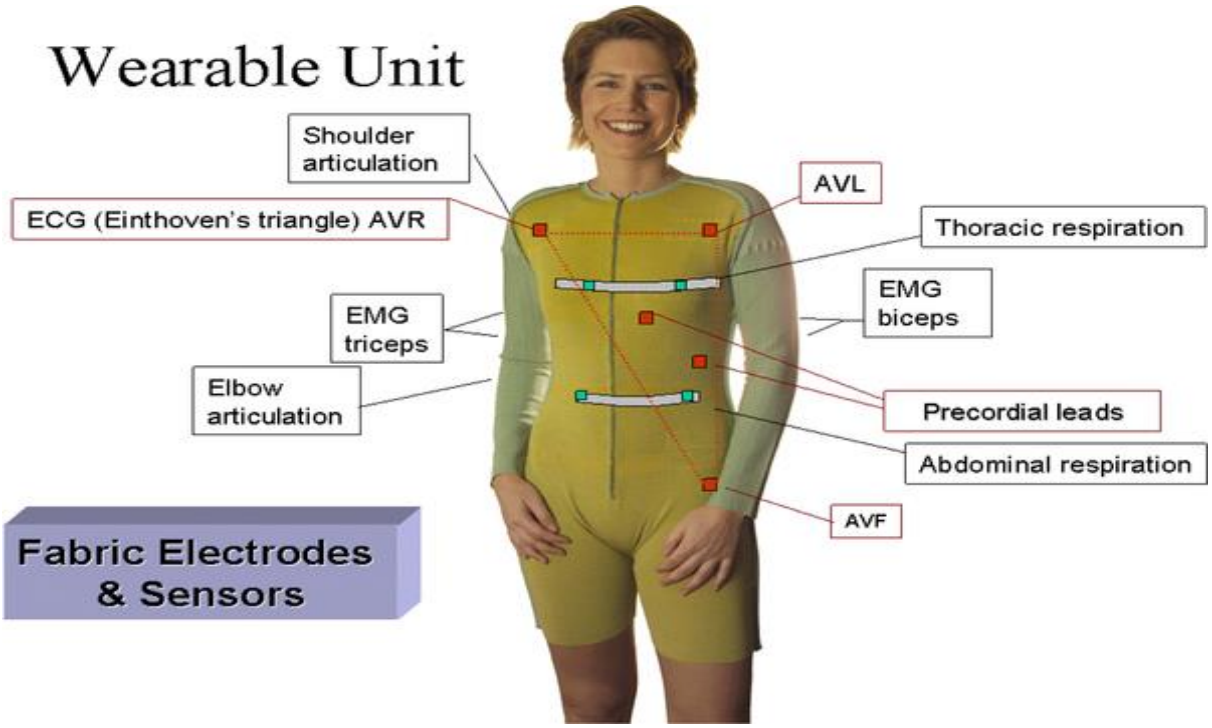


Source: Gibson et al. 2016, Sensing environment with fall detection system, [Image], Retrieved from: http://www.sciencedirect.com/science/article/pii/S1568494615007061#fig0010

Source: MobiHealthNews, 2017, *Philips Lifeline, Royal Philips' personal emergency response system (PERS)*, [Image], Retrieved from: http://www.mobihealthnews.com/31702/philips-lifeline-launches-home-based-cellular-pers-mpers-still-to-come

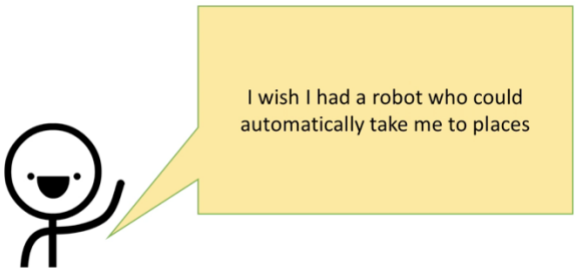
Source: ILCA 2011, *Products and services to help people remain independent and improve their quality of life*, [Image],

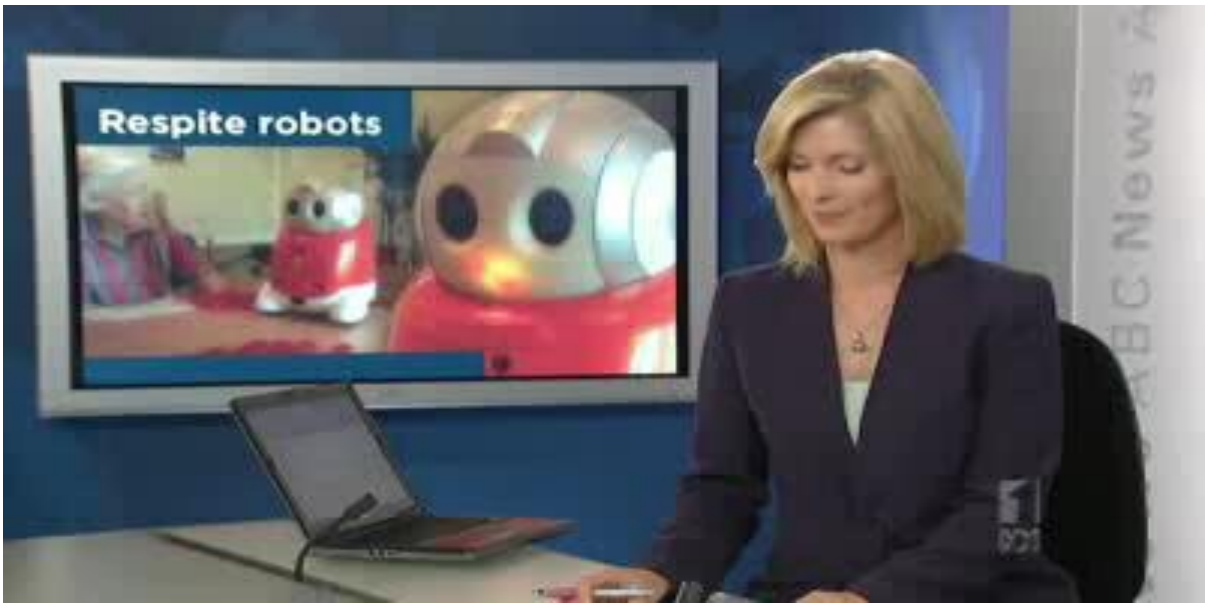
Retrieved From:http://ilcaustralia.org.au/search_category_paths/309



Source: Patel et al. 2012, *Example of e-textile system for remote, continuous monitoring of physiological and movement data,* [Image], Retrieved from: https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-9-21

Clips from the Video shown in Introductory Session to the participants




Respite robots

APPENDIX D: IEEE LSC CONFERENCE PROCEEDINGS 2017- PUBLISHED PAPER

Barriers in acceptance of Ambient Assisted Living Technologies among Older Australians*

Chetna Maan.[1], Upul Gunawardana[2]

Abstract— **One of the great challenges facing Australian society is the ageing population. Amongst various issues involved in this drastic demographic change, the most significant aspect is the demand for older Australians to be able to live independently at home. One of the things done to address these issues is the development of Ambient Assisted Living (AAL) technologies. However, the optimum uptake of these technologies among the end-users (the elderly Australians) still remains a big concern. This aim of this study is to investigate the barriers and perceptions in the use of AAL applications amongst older Australians. Focus groups, and quantitative surveys have been conducted to provide the detailed analysis of these impediments. The results show that there are different factors that restrict the use of these technologies and elderly people have certain preferences when using the technology. An understanding of these barriers is gained to provide solutions according to user needs.**

INTRODUCTION

Recent developments in medicine and technology have helped the people lead a healthier and longer life in comparison to previous times. In fact, the population of older people (above 65) among the world population is expected to double by 2050 [1]. The demographics of Australia show that the percentage of the elderly is the highest increase among the total population of Australia [2]. According to the Australian Bureau of Statistics, the number of people above 65 in Australia is anticipated to increase by 84.8 percent from 3.1 million to 5.7 million between 2011 and 2031[3]. These demographic changes will lead to economic and social impacts including a reduction in the per capita output [4] and rising demand for aged-care aids. Thus, it will also lead to new challenges for the government. The ageing population will be a big concern for health care system and will bring new challenges for the society. There will be an accretion of diseases related to ageing, like Alzheimer's and there is no cure for them yet [5]. It is estimated that there will be a rapid surge in the health care costs in Australia in coming years [6]. The undersupply of caregivers for the elderly impacts the physical and mental health of the informal caregivers like family and friends [7].

The demographic trends result in the difficulties associated with the elderly's life which encompasses health, mobility and independence, care and utilization of social care services [8]. These challenges necessitate the new strategies for reliable, self-sustainable, technological tools. Ambient Assisted Living (AAL) technology is seen as an evolving innovation that holds the potential to support the changing needs of the elderly.

I. AMBIENT ASSISTIVE LIVING TECHNOLOGIES

Assisted living provides the electronic environments that attend and respond to the presence of the people [9]. AAL includes the intelligent systems designed to monitor, assist and promote the healthy environment to enhance independent living for elderly people [10], [11]. Using ambient intelligent notion, AAL tools are employed with a common objective to empower the elderly and disabled with special needs, help them live independently in domestic environment ,assist them with routine activities, and provide health monitoring and treatments at home to reduce the cost of nursing home care [12]–[14]. The beneficiaries of AAL solutions are wide-ranging. The main end-users are the elderly who directly benefit from the aiding technology. The secondary users are the people associated with the elderly like family members, relatives, friends and care institutions. Others include the health organizations including hospitals, insurance associates and public security firms [15], [16].

Recent research is working towards advancements of these technologies. Within the past decade, AAL technologies have been an important research area with an aim to improve the assistance available for elderly people and to provide ubiquitous care at home. AAL technologies have been able to support aged people with increasing their mobility, helping with security, obtaining treatments remotely and becoming more active socially. Smart home technology, as a representative of AAL, is the most established form in the market with a wide range of consumers [17]. Formulation of smart homes (SH) has always been focused on consideration of privacy while providing assistance to improve the elderly's quality of life. In recent years, smart home applications have been developed for saving energy, increasing safety, tracking falls, sensing smoke and fire and space illuminating management by integrating various tools such as actuators, sensors, internet and alarms to monitor and collect data [18]. SH incorporates multiple information and communication technology (ICT) solutions and protocols like ZigBee, Bluetooth, and programmable logic controller (PLC). Contemporary research has found wearable sensors as the most popular kind of AAL technology within health care [19]. Wearable devices are the electronic sensors that can be worn and are capable of continuously monitoring the internal health of a person without restricting the motion. Existing wearable

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electronics are able to monitor only the physical activities of an individual. However, research has been undertaken to develop sensors that can monitor user's health at molecular levels. Presently, intensive research is being conducted to develop mobile robots, within the context of smart home environments [20]. It is because of the need for integrating artificial intelligence within the AAL sphere. The elderly's need to be able to monitor things remotely and get help in physical activities has led to work on developing mobile robots. This will help in increasing the elderly's mobilisation and access to transport [21].

However, while there has been significant research on the development and improvement of the AAL technologies [23], minimal research has been conducted on user acceptance and uptake of these technologies [23], and particularly within Australia. The use of these technologies, in the real world, is still limited and thus, it is imperative to explore the major hindrances for the adoption of these technologies [24].

II. Barriers in acceptance of AAL technologies

Reviewing of literature shows that previous work has tried to know user acceptance and trust in AAL technologies [23] [25] [26]. Previous studies show that the major barriers and challenges in the adoption of AAL technologies connect to one of the following factors: home safety and security, lack of awareness and training, size intrusion and weight intrusion of technological devices, privacy, family acceptance and culture. Some of the concerns raised by the older people in the past were the lack of experience in choosing the right technology. Thus, more access to digital training needs to be provided for older people to be able to understand the benefits from the use of the assisted living devices.

Most elderly people stick to their old lifestyle and refuse to accept any changes in their behaviours or daily life. They also fear that the uptake of these technologies could lead to a reduction in human interaction. They don't want technology to replace the communication with the family members, friends, nurses, etc. The elderly people are worried about misuse of their personal information and resist from being monitored by cameras and other forms of technology [26]. The lack of government support is one of the major barriers [27]. The elderly people are unwilling and sometimes incapable of accounting for the money needed for installation and maintenance of the technological devices.

However, there is lack of similar studies within Australia. Thus, there is need to undertake the thorough study for knowing the major issues, within the context of designing these technologies. Thus, this pilot study investigates the major barriers preventing older Australians from using these technologies. The main aim is to demonstrate the major issues faced by elderly Australians as the primary objective of the research. The secondary objective of the study is to explore, in detail, the factors that have never been addressed in previous studies most of which have been done elsewhere. The study elicits the results in terms of user needs for technology design. It is relevant to mention that the study aims to understand the concerns, attitudes and preferences of the users from a technology perspective rather than a psychological point of view.

III. Methodology

The study has used mixed approaches through a combination of written questionnaire and qualitative methods such as focus groups. The authors developed the questionnaire and focus group questions with an aim to survey 30 participants, to be selected on the basis of selection criteria which was also indicated on the recruitment flyers. The main selection criteria included the age of the participants to be above 65, their ability to understand English and to be able to consent independently. Out of over 100 eligible who were informed, 25 interested participants signed up to participate in the research.

Prior to the focus group discussions and filling out the questionnaire, the participants were introduced to AAL technologies through a video. The video included AAL technologies like smart homes shown through an example of an assistive living facility in USA called Elite Care, Respite robots in a Melbourne nursing home, wearable technologies for health monitoring from Intel, walking assist device from Honda, Lifeline Phillips- auto alert device for fall detection and emergency, Medication dispensing device by Phillips.

Qualitative data was collected through three focus groups conducted at three different Anglicare Retirement Villages. The focus group discussion was based on five main themes which were drawn from the literature review done on the barriers to acceptance of AAL technology among older people. The five questions for the discussion focused on identifying main barriers in acceptance of the AAL technologies, and on gaining more informed understanding of the needs of their end-users. The audio recordings were transcribed followed by content analysis.

A written questionnaire was composed inductively based on the knowledge derived from the literature review conducted on types of existing AAL technologies. The survey comprised of four types of questions. Firstly, there were six dichotomous questions to get distinct values about the opinions of the elderly. Secondly, there were fifteen multiple-choice questions, most of which were similar to Likert-scale measurement, to determine the extent of the seniors' attitude towards AAL technologies. Thirdly, the questionnaire included three "fill in the blanks" type questions to record accurate demography of the participants. Finally, there were optional open-ended follow -up section to add comments to the answered questions regarding preferences and concerns of the elderly. There was a total of 24 units in the questionnaire. The acceptance rate of the survey was quite high with 72% participants answering the full questionnaire.

All 25 participants who were recruited initially, agreed to take part in the study. The data analysis infers that the majority of the participants were female (68%), whereas males accounted for 32% of the total participants (n=25). The participants included in the study aged between 67 and 89, all of them with Australian background and 96% have English as their first language. 40% of the participants are school leavers, 20% have vocational degrees, 16% have bachelor's degree and 4% have Doctoral degree. All the participants live independently and are from Greater Sydney.

IV. RESULTS AND FINDINGS

The study identified few barriers, concerns and preferences for older Australians in the adoption of AAL technologies. These are summarized under the following categories:

A. Human Connection:

Fear of losing human contact was reported as the main barrier with 100% respondents. The older people are worried about technology replacing human care. In fact, they prefer family or professional aged-care over technology for the medical purpose with 60% respondents agreeing to it.

Participant x: "I am concerned about technology replacing human care."
Participant y: "Just the human touch, you need."
Participant z: "Nothing will replace the human carers who can give you the medicines."
Participant u: "I don't think you can replace human care."
Participant v: "Need someone to talk to, from care point of view."
Participant y: "Human care is important."
Participant a: "you need personal contact as well. One on one talking, laughing and singing. You know all this kind of activities."
Participant b: "If you bring the technologies, it should not affect the human role in our lives."

B. Lack of awareness:

93% participants reported that the lack of awareness would hinder the adoption of AAL technologies for them. Most of them were not aware of these technologies before the session. Those who were aware were familiar about technologies like alert button and sensors. The participants also indicated the lack of availability of these technologies to be a major barrier.

Participant u: "That sort of information about what's available for different issues could be really useful. For example, a lot of people could be living with arthritis and they could access help from these technologies if they know what's out there".

B. Ease of use:

Another major barrier was found to be the difficulty seniors face in using the technology with 96% respondents. They find the technology very complex and hard to understand.
Participant x: "We had an alert button at one of the resident's places I didn't know how to help her. We had to call other people to know how to use it. We couldn't get into the house, had to call the police. We did learn where the key was. We got to know for the next time".

C. Digital literacy:

The lack of training in using these technologies was reported to be a barrier by 71% respondents. In fact, 72% participants find it hard to understand the language associated with the technology and more than half of them would prefer to get personal training in using AAL devices.

D. Cost:

Cost is found to be a major factor restricting the use of AAL technologies among the elderly, with 87% respondents. Participants have regard for the government support in being able to access these technologies. There is an established connection between the cost and its perceived usefulness with 74% participants agreeing to pay for the technology if they find it useful.

Participant e: "I am horrified by the cost."
Participant c: "You can't get these technologies because it would take all your savings away."
Participant b: "If the government is going subside it in some way and it's going to bring down their price to look after someone, it has to work both ways. Depends on the benefit to somebody."
Participant d: "This really comes down to what somebody needs."
Participant e: "I will save to buy a good program."

Additional factors that affect the use of these technologies were reported through the open discussion in the focus groups. 40% of the participants desires the technology to be invisible and unobtrusive while 44% questioned their reliability.

E. Concerns, Attitudes and Preferences:

In addition to the barriers that restrict the adoption, the elderly also presented some concerns with the use of AAL technologies. Most of the participants (93%) mentioned that they had concerns while being monitored by the cameras while one of the participants stated that she would not mind being monitored if it was concerned with her health and safety. On the other hand, 93% of the participants reported that were fine being monitored by sensors. Furthermore, a few of them prefers to get help from technology in case of fall events or other emergencies. Some of the respondents (68%) said that they are worried about health hazards caused by the use of these technologies. There was noticeable interest among participants to know the role of AAL technologies in helping the people with health issues like Alzheimer's.

The participants expressed their concerns about reliability of the technology. Some of them are reluctant to use technology because of their comfort zone.
Participant u: "We didn't grow with that, so technology didn't come naturally to us."

However, they are happy to use these technologies for daily-life activities like cleaning, gardening, personal grooming and other house-hold activities. Family support is considered to be helpful by the participants (81%) in making the technology easier for them to use. Connection with the community and engagement in activities that make them active and healthy is important for the seniors. Overall, the participants were ready to accept these technologies if the barriers could be managed. They also indicated that they would like to access AAL technologies through a common place like My Aged Care, a service provided by Australian government to access aged care services [28]. The respondents prefer these technologies to be integrated with current facilities rather than making efforts to access these technologies separately. The participants found the video on

introduction to these technologies very informative and were excited to see and get support from them in the future for certain activities.

V. CONCLUSION AND FUTURE WORK

Ambient Assisted Living technologies have significant capability in providing the aid to aged care services and aged care professionals, therefore, reducing economic and social implications of an ageing population. Although the results from this study were found to be in alignment with the results from previous studies, there were some distinguished differences in the perception of these technologies among older Australians.

Thus, the project will work towards improving the utilization of this technology thereby supporting the government in the up taking of policies to answer the demand for increased aged care services. This is an ongoing project with an aim to conduct further study while targeting a total of 40 participants and include individual interviews as an additional methodology to elucidate more details for answering the research question. It is aimed to expand the study in future while incorporating the AAL technologies so that the participants (older Australians) can understand their benefits more clearly.

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ETHICS APPROVAL

This study was approved by The Western Sydney HREC (human research ethics committee) (REDI reference: H12251) in compliance with the National Statement on Ethical Conduct in Human Research [29].

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