

## **ASSISTIVE TECHNOLOGIES FOR AGED CARE: SUPPORTIVE OR EMPOWERING?**

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### **ABSTRACT**

The main objective of this paper is to explore the potentials of assistive technologies to support seniors' independent living. The work looks at two salient aspects of utilizing technologies for elderly, namely direct support and empowering technologies. The research undertakes a comprehensive analysis of attempts that have been made through investigation of the literature. For this purpose, a realist review of relevant papers published since 2000 has been conducted. The paper concludes that although much research in this area targets the direct support for older adults, the effective use of technologies to maintain seniors' physical and cognitive abilities requires further investigations. This can provide avenues of opportunities that would empower seniors for their independent living.

### **INTRODUCTION**

Owing to a substantial decline in the age-specific mortality, the world's population is ageing rapidly. In 2012, 6.9% of the world population were more than 65 years old, and this is estimated to increase to around 20% by 2050 (OECD, 2012). What was before a small number of exceptional old individuals is rapidly becoming a whole new generation for families and the society? The elderly have lived long enough to have acquired, on average, several medical conditions, and a range of age-associated impairments of bodily and mental functions. This has led to concern as to whether existing care provision will cope with the predicted future demand (Australian Nursing Federation, 2012). Also, it is commonly believed that seniors would like to live independently at their home (Porteus and Brownse, 2000). However, the issue is the fact that whether their home is compatible with their physical and cognitive conditions (Leeson et al., 2004). In this perspective, assistive technologies provide aid for elderly, but are underutilized to offer effective training of skills that are required for independent living.

Marshall, (1997) (Marshall, 1997b) has defined assistive technology in the context of aiding seniors with disabilities as "any item, piece of equipment, product or system, whether acquired commercially, off-the-shelf, modified or customized, that is used to increase, maintain or improve functional capabilities of individuals with cognitive, physical or communication disabilities". The above definition has an emphasis on disabilities in seniors. A more recent definition has been given by the Australian Dementia Resources Guide (DOHA, 2008). This guide defines "assistive technologies as a product, equipment or device, usually electronic or mechanical in nature, which helps people with disabilities to maintain their independence or improve their quality of life". This definition has extended the use of

assistive technologies from devices to help older adults with disabilities to products facilitating seniors' with their daily life activities. Our definition of assistive technology is most closely related to the Dementia Resources Guide definition, although we look at assistive technologies in a boarder sense than only being used for dementia patients.

While recent advancements in Information Technology (IT) have resulted in cheap off-the-shelf products that can have potential to assist older people in their daily life activities at their home (Miskelly, 2001), less is known on how these technologies can assist seniors. In other words, despite the existing body of literature in technologies that can assist elderly, the bigger picture of research on what are the real potentials for these technologies is missing. Our exploratory search on application of assistive technologies in aged care (Vichitvanichphong et al., 2013) has shown that there are very limited studies that aim to empowering seniors by training and maintaining the skills that are necessary for independent lifestyle. Instead, work around this topic has been based more on introducing technologies that directly support elderly in their daily living.

In response to the above mentioned concerns, this paper aims to look at the technologies that have been used for aged care and identifies the potentials of these technologies. The ultimate aim of this work is to better understand how technologies can be utilized in this setting. Therefore, researchers and professionals would be aware of salient approaches that assistive technologies can be effectively utilized for seniors. This paper seeks to answer the following research questions:

*What are the potentials of assistive technologies for seniors' independent living?*

For this to be answered, we seek to identify the available technologies. We also look at the attributes of these technologies and how they open up potential opportunities for effective approaches in utilising technologies in aged care.

In order to answer the question, the present research has taken a realist review approach as suggested by (Pawson et al., 2005). We have systematically searched papers and extracted relevant data to the questions. From these papers, we have also conducted some characteristics of the research in this area e.g. research method, or geographical distribution etc.

## METHOD

We customized the guidelines for realist reviews laid down by (Pawson et al., 2005). The reason why we chose to follow the realist approach was that it has been proven (Macaulay et al., 2011) as an effective way of reviewing complex interventions with social aspects, which implies to the matter of technology adoption among seniors. The realist review proposes six steps to carry out a literature review; (1) Exploratory background search to identify the relevant keywords and databases, (2) Searching for the initial list of studies, (3) Relevance appraisal, (4) Extracting data, (5) Analysis of data and finally, (6) Evaluation. In the following sections, we explain the process that we have conducted in our realist review of literature associated with the adoption of assistive technologies among seniors.

### **Exploratory background search: identifying keywords and databases**

The first step towards searching the articles was to identify the relevant keywords and online databases. we have conducted a background survey (Vichitvanichphong et al., 2013) in two topic areas; Medical Informatics and Information Systems. These areas have been selected due to the focus of this review to the assistive technologies among seniors. An initial list of journals has been chosen from the journal classification list proposed by Excellence in Research for Australia (ERA, 2012). The relevant journals were selected and the journals with an impact factor of less than one were omitted. As such, we came up with 14 journals regarded as popular outlets of publication in this area. We have found 31 relevant papers published in these journals, since 2009.

In order to identify the relevant keywords and related online databases, we have implemented the experimental method proposed by (Dieste et al., 2009). The method was applied in the above-mentioned 31 papers and identified most popular online databases indexing these 31 papers, also the most popular keywords relevant to “aged care” and “adoption” used with “technology”.

### **Searching the initial list of papers**

Following the search instructions given by each database and using the most popular relevant keywords identified in the background search, we required that the relevant articles contain the word “Technology” along with any of “aged care”, “aged”, “aging”, “senior”, “old”, “elderly”, “elder” or “older” in their titles, keywords, abstracts or full texts.

Eight popular databases were searched using the above keywords. The search considered titles, keywords, abstracts and full texts of papers published since 2000, inclusive and returned 723,944 articles. The distribution of papers in each database is presented in Table 1.

### **Relevance appraisal**

In this step, the objective was to filter relevant papers from the initial list and exclude the ones which are not related to our study. This process was carried out by excluding papers based on titles, keywords, abstracts and full texts; see Figure 1. Articles that have one of the following exclusion criteria were removed:

- Did not focus on assistive technologies for aged care.
- Did not have any empirical evidence.
- Were in languages other than English.
- Were not in the relevant fields or could not be applied to relevant fields.
- Were not peer reviewed.
- Were not available online.

| Name of Database  | Initial list of papers | Filtered by titles    |                           | Filtered by abstract  |                           | Filtered by text      |                            |
|---|------------------------|-----------------------|---------------------------|-----------------------|---------------------------|-----------------------|----------------------------|
|   |                        | No. of found articles | No. of duplicate articles | No. of found articles | No. of duplicate articles | No. of found articles | No. of duplicated articles |
| Springer  | 16,539                 | 213                   | 22                        | 31                    | 11                        | 18                    | 6                          |
| Wiley InterScience  | 453,537                | 99                    | 15                        | 17                    | 8                         | 11                    | 5                          |
| Science Direct  | 11,442                 | 49                    | 18                        | 38                    | 16                        | 32                    | 10                         |
| IEEEXplor   | 69,690                 | 30                    | 13                        | 22                    | 12                        | 16                    | 6                          |
| ACM Digital Library   | 560                    | 21                    | 6                         | 14                    | 5                         | 10                    | 3                          |
| Scirus  | 94,487                 | 27                    | 7                         | 18                    | 6                         | 14                    | 4                          |
| PubMed  | 10,989                 | 33                    | 9                         | 25                    | 8                         | 18                    | 6                          |
| Google Scholar  | 66,700                 | 160                   | 122                       | 48                    | 16                        | 39                    | 14                         |
| <b>Total</b>  | <b>723,944</b>         | <b>632</b>            | <b>212</b>                | <b>213</b>            | <b>75</b>                 | <b>158</b>            | <b>54</b>                  |
| <b>Relevant papers by deducting the duplicated articles</b> |                        | 420                   |                           | 138                   |                           | 104                   |                            |

Table 1 Distribution of papers in each online database.

Among 723,944 papers indexed in the databases and searched by the keywords, 420 papers were remained after title filtering, 138 articles were remained after abstract filtering and 104 papers were identified as final list of relevant papers after reading the full texts. We also found some of the papers were indexed by multiple databases, see Table 1. It is notable that we used Zotero (<http://www.zotero.org/>) for reference management.

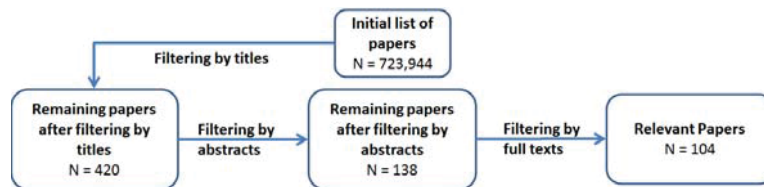


Figure 1 Relevance appraisal process

**Extracting data**

In the data extraction stage, key details from the selected papers were obtained. Three types of data were collected from each paper:

- Technology options: we identified what technologies have been used in each paper to assist seniors.

- **Demographics:** In order to analyze the characteristics of the research in this area, we have collected demographic details such as research methods, fields of publication and geographical distribution each relevant paper.

In order to ensure the reliability of the results, we used standard critical review forms for quantitative (Law et al., 1998a) and qualitative studies (Law et al., 1998b). For mix-method studies, we completed both forms.

### Analysis of data

In order to answer the research question, we identified the classification of technologies that have been used to assist elderly i.e. technology options. We also identified the main research areas. In these analyses, we used the process proposed by (Ghapanchi and Aurum, 2011). In order to answer to the research question, and identifying the technology options, the process involved extracting the terms and definitions used in the final list of selected papers, and eventually forming the primary list of technologies. It broadly categorized the factors as well as the technologies. The process is depicted in Figure 2.

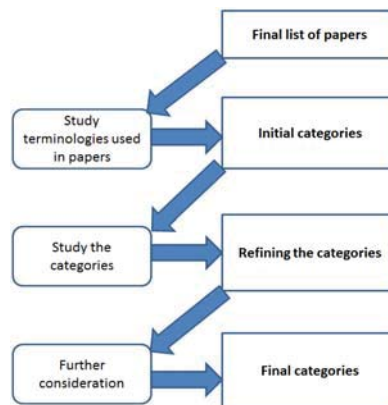


Figure 2 Data analysis process.

### Peer evaluation and reliability testing

A peer review of the findings for the interventions and factors impacting the adoption of technologies among seniors was undertaken. Four experts from North America, Australia, Europe and Asia were invited to code both interventions and impacting factors of adoption into categories. The experts were chosen based on their academic knowledge and practical experience in the topic. The experts were given an instruction sheet including the description of all the items as well as an answer sheet in which they were asked to map the items into the proposed categories.

A reliability test was then undertaken based on proportional reduction in loss (PRL) reliability indicator introduced by (Rust and Cooil, 1994). PRL is used to assess the consensus between judges who are invited to code a number of elements into exclusive categories. In addition to the four experts, we have considered the proposed contributions of this work as one coding. Therefore, the total number of judges was five. Inter-judge agreement was measured by dividing the total pair-wise agreements by the total pair-wise decisions. Having five judges onboard; in assigning each item into a category, a total number of 10 pair-wise decisions were made. The consensus of assigning an item to a category was the most frequently selected choice by the five judges. The reliability for each contribution was calculated based on the value of Inter-judge agreement. The number of pair-wise agreements was 169 out of the total

270 pair-wise decisions, which calculates 0.62 inter-judge agreements and 78% reliability of the results. Therefore, based on (Rust and Cooil, 1994), the reliabilities of contribution in this paper are acceptable.

## FINDINGS

In this section, we present the results of our investigation on the technology options, and demographics of the research in assistive technologies for aged care.

### Technology options

As described in this section, we have categorized technologies that have been adopted in 104 relevant papers into 7 categories; general purpose ICT, social media, games, robots, online information services, smart home and remote care, and supportive devices.

It was found that general purpose ICT and smart home and remote care were the technologies that most of the interventions have been focused, see Figure 3.

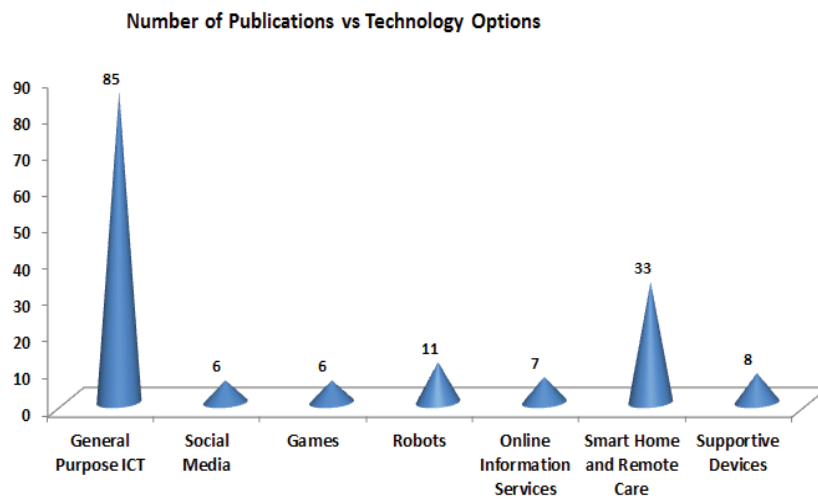


Figure 3 Distribution of papers over different technology options

The first category is ICT in general purpose and this includes technologies such as mobile phones, the Internet, email, etc. Seniors have been using these technologies to cope with the transition period or life style change after retirement or to communicate with family, friends and caregivers; see Table 3. These technologies are well established and not considered innovative any more. We consider the use and adoption of these well-established technologies to be relatively straightforward and requiring more of an educational training approach as community pressure will play an important part in older people adopting and using these technologies. These devices are becoming increasingly mainstream and part of everyday society much like television or the home phone.

| Technology                       | Sample of Adoption  |
|----------------------------------|---|
| Email                            | <p>“...Elderly can enhance their self-esteem and decrease loneliness by remaining in contact with the world via e-mail. The Internet and e-mail are means to keep in touch with the world... (Kiel, 2005)”</p> <p><i>Other(s):</i> (Hiroyuki Umemuro, 2004); (Haase et al., 2012); (Adams et al., 2005); (Selwyn et al., 2003); (Melenhorst et al., 2006); (Rosenberg et al., 2009); (Singh et al., 2009)</p>   |
| Mobile/smart phone               | <p>“...Using the mobile health services/ smart phone will improve seniors’ life quality and make seniors more effective in their lives. For example, seniors use mobile phone to communicate with family, friends, and carers any time they need... (Guo et al., 2013)”</p> <p><i>Other(s):</i> (Conci et al., 2009); (Xue et al., 2012); (Ahn et al., 2008); (Barnard et al., 2013); (Renaud and van Biljon, 2008); (Häikiö et al., 2007); (Xue et al., 2012); (Mallenius et al., 2007); (Walsh and Callan, 2011); (Melenhorst et al., 2001); (Haase et al., 2012); (Boontarig et al., 2012); (Kubik, 2009); ((Boni) Li and Perkins, 2007); (Neves, 2012); (Rosenberg et al., 2009); (Hardill and Olphert, 2012); (Salovaara et al., 2010); (Copolillo and Prohaska, 2001); (Biljon and Renaud, 2008);</p>   |
| Digital camera                   | <p>“...Older adults is able to increase their memories as well as enhance their quality of life through using digital camera...(Salovaara et al., 2010)”</p>  |
| MP3                              | <p>“...Listening to music on MP3 player instead of an old radio help seniors to perform task better and enhance independence and quality of life...(Salovaara et al., 2010)”</p>  |
| GPS                              | <p>“...The Global Positioning System (GPS) provides seniors advanced means of communication and support the use of different modalities which makes seniors’ lives a lot easier...(Salovaara et al., 2010)”</p>   |
| Personal Digital Assistant (PDA) | <p>“...PDA helps seniors to execute day-to-day duties as well as storage information, which is an important tool for managing their lives... (Wilkowska and Ziefle, 2009)”</p>  |
| Computer                         | <p>“...Using computer makes older adults independent. Computers can fulfill both types of activities—acting for some people as a means to ‘keep the brain ticking’ and ‘filling a void in seniors’ lives’...(Selwyn, 2004)”</p> <p><i>Other(s):</i> (Aula, 2005); (Cameron et al., 2001); (Ahn et al., 2008); (Mitzner et al., 2010); (Abdullah et al., 2011); (Czaja et al., 2008); (Giuliani et al., 2005); (Lam and Lee, 2006); (Walsh and Callan, 2011); (Kiel, 2005); (Melenhorst et al., 2001); (Burnett et al., 2011); (Czaja et al., 2006); (Haase et al., 2012); (Hernández-Encuentra et al., 2009); (Morris et al., 2007); ((Boni) Li and Perkins, 2007); (Neves, 2012); (Selwyn et al., 2003); (Rosenberg et al., 2009); (Wood et al., 2005); (Karavidas et al., 2005); (Sayago et al., 2011); (Carpenter and Buday, 2007); (Salovaara et al., 2010); (H. Umemuro, 2004)</p>         |
| Internet                         | <p>“...Functional abilities in daily activities of older adults can be boosted by using the Internet. Older adults use the Internet for communication, seeking information, commercial purposes, etc. Eventually, using the Internet can enhance seniors’ well-being...(Sum et al., 2008)</p> <p><i>Other(s):</i> (Nayak et al., 2010); (Aula, 2005); (Cameron et al., 2001); (Sum et al., 2009); (Hanson, 2010); (Pan and Jordan-Marsh, 2010); (Mitzner et al., 2010); (Abdullah et al., 2011); (El-Attar et al., 2005); (Czaja et al., 2008); (Lam and Lee, 2006); (Kiel, 2005); (Melenhorst et al., 2001); (Czaja et al., 2006); (Haase et al., 2012); (Hernández-Encuentra et al., 2009); (Morris et al., 2007); (Adams et al., 2005); (Eastman and Iyer, 2004); (Neves, 2012); (Melenhorst and Bouwhuis, 2004); (Rosenberg et al., 2009); (Sum et al., 2008); (Choi and Dinitto, 2013)</p> |

Table 3 Technology options: general purpose ICT

The second category is social media. Increasingly, we see seniors becoming isolated from social activities, usually after the loss of a partner and this, combined with the desire to live independently in their own home, leads to a loss of previously established social networks. Researchers have used social media to engage seniors in the community and to increase their social interactions by staying in touch with people, establishing friendships and gaining information, even sharing thoughts and experiences; see Table 4. Social media technology is relatively new and requires a mindset of ubiquitous access and this usually entails the use of newer technologies such as tablets, smartphones or laptop computers to be truly effective. The adoption of these newer technologies could be more problematic for older people and there needs to be well thought out processes in place to incentivize adoption for this older generation.

| Technology            | Sample of Adoption   |
|-----------------------|--|
| Online social network | <p>“...To decrease loneliness as well as enhance (health) communication for older adults, social network or social media is a great tool used by them. Using online social network, particularly comprehensive social network platform like facebook, allows seniors to keep up in the day to day lives of important others, for example...(Braun, 2013)”</p> <p><i>Other(s):</i> (Heinz et al., 2013)</p> |
| Online community      | <p>“...Online community is increasingly being incorporated into the everyday routines of older adults. Engaging in online community can improve seniors’ quality of life and decrease loneliness...(Chung et al., 2010)”</p> <p><i>Other(s):</i> (Ryu et al., 2009); (Wong et al., 2012)</p>   |

Table 4 Technology options: social media

Another category is games; either video games or mobile games. Many older adults have a connection with traditional games such as card games like bridge and board games like Monopoly. This could easily be extended to the electronic media and research has shown that older adults can use video or mobile games as a therapy tool and for entertainment, relaxation and socialization; see Table 5. We found games, because of their interactive nature can also be used to improve seniors’ cognitive skills and this can help them in their functioning for their daily lives. Cognitive research has found that this could be a very significant feature in improving daily living for seniors and that gaming can provide a proactive approach by improving seniors’ living skills. In fact, this approach could provide brain training before the elderly start to need assistance and thus reduce the resources needed to facilitate daily living further down the track. We will discuss this aspect later.



| Technology  | Sample of Adoption  |
|-------------|---|
| Video game  | <p>“...Video games increasingly used as a therapeutic tool in health and aged care settings. The use of interactive video games as a therapy tool for addressing both physical and cognitive function is a growing trend in the health and aged care sector ...(Laver et al., 2011)”</p> <p><i>Other(s):</i> (McKay and Maki, 2010); (McLaughlin et al., 2012); (Heinz et al., 2013); (Wood et al., 2005)</p> |
| Mobile game | <p>“...Mobile games can benefit seniors in terms of entertainment and relaxation, socialization, mental challenges and physical fitness...(Chu Yew Yee et al., 2010)”</p>   |

Table 5 Technology options: Games

Robots are also a well-known technology option in this research area. Social robots have been used in health-related settings (see Table 6) and research has found that for seniors to adopt robots in their daily lives, they need to build a long term relationship with the robot. Intelligent, interactive social software can assist seniors in an interactive way and help them with daily living chores. Social robots are hardware robots that physically assist the elderly. This area of research looks promising; however there are major obstacles with respect to adoption that needs to be overcome. For example many older people would have problems with the concept of building a long term relationship with a machine (robot) and this concept may need to be modified to allow for human wants and emotional needs. This is very culturally and country specific however, the level of acceptance of long term machine/people relations could vary according to cultural norms.

| Technology                  | Sample of Adoption  |
|-----------------------------|---|
| Interactive social software | <p>“...Using interactive social software at home as assisted therapy and physical and cognitive assistant can help seniors to improve quality of life, execute day-to-day activities as well as mental health...(Heerink et al., 2010)”</p> <p><i>Other(s):</i> (Bickmore et al., 2005b)</p>  |
| Social robot                | <p>“...Social robots are looked upon as potential aids to improve the quality of life of older adults, help them live independently and help relieve the stress of their caregivers...(Klamer and Ben Allouch, 2010)”</p> <p><i>Other(s):</i> (M. Heerink et al., 2008); (Heerink, 2011); (Heerink et al., 2006); (Ng et al., 2012); (Smarr et al., 2012); (Marcel Heerink et al., 2008); (MITZNER et al., 2011); (Neven, 2010)</p> |

Table 6 Technology options: robots

As seen in Table 7, it was also found that online information services have been popularly used in this cohort e.g. using online health service to seek and update health information, electronic health records and to make health information more accessible to patients for the management of chronic conditions. The acceptance of these services would be very much associated with context. For example, a healthy person would find little need to access information on diabetes, unless they receive a diagnosis of the disease so we would expect high adoption rates for people suffering chronic disease, especially if they are having difficulty in managing the condition.

| Technology                | Sample of Adoption   |
|---------------------------|--|
| Online health services    | <p>“...Online health services aid older adults to maintain their independence and quality of life...(Ryu et al., 2009)”</p> <p><i>Other(s):</i> (Steele et al., 2009a), (Heinz et al., 2013)</p>   |
| Electronic health records | <p>“...Electronic personal health records (PHRs) have the potential to both make health information more accessible to patients and function as a decision-support system for patients managing chronic conditions. Elder people tend to use PHRs to help them to manage in health related information, which is convenient, beneficial, and productive in comparison to the paper based...(Price et al., 2013)”</p> |
| Online daily services     | <p>“... Older adults use eService to shop, check prices, choose shipping methods and then pay and complete the transaction online which help them to increase self-actualization and independence...(McCloskey, 2006)”</p> <p><i>Other(s):</i> (Phang et al., 2006)</p>  |
| Online learning           | <p>“...Online learning is a great tool to empower adult learner. Seniors use online learning to improve cognitive abilities, maintain independence and enhance their quality of life...(Chu, 2010)”</p>  |

Table 7 Technology options: online information services

The Smart home and remote care technologies are also used to help seniors balance safety and independence through remote monitoring, motion detecting sensors and fall alarms technology. Furthermore, telecare has been used for balancing safety and independence purposes and like the smart home products it includes the provision of support for seniors who have dementia; see Table 8. One of the interesting interventions is to use motion detection sensors to monitor seniors' movement around the house, while living alone, for two purposes: (A) to monitor elderly and automatically detect their falls, and inform the authority, family or friend for primary aid (Sarkisian et al., 2003), (B) to monitor seniors and automatically notice any radical changes in their functional or movement abilities, which may need serious and further treatments (Goins et al., 2010). These technologies provide direct assistance to the elderly and are usually adopted with the thought that there is no other option but to adopt. Usually these devices are installed with the ultimatum (from family and friends or health authorities) that if it is not adopted the aged person will have to leave their home and go into a residential care facility. This can force the individual into acceptance depending on how much they value their independence.

| Technology              | Sample of Adoption   |
|-------------------------|--|
| Remote monitoring       | <p>“...Remote monitoring technology install and operate in seniors’ homes with the purpose of improving their quality of life and monitoring their health status...(DEMIRIS et al., 2004)”</p> <p><i>Other(s):</i> (Ahn et al., 2008); (Courtney, 2008); (Mitzner et al., 2010); (Conci et al., 2010); (Wong et al., 2012); (McCREADIE and Tinker, 2005); (van Hoof et al., 2011); (Courtney et al., 2008); (Mynatt et al., 2004); (Goins et al., 2010); (Steele et al., 2009b); (Ahn et al., 2008); (Steele et al., 2006); (Beer and Takayama, 2011); (Wong et al., 2012); (Or et al., 2011); (Bickmore et al., 2005a); (Selwyn et al., 2003)</p> |
| Motion Detecting sensor | <p>“...Elderly people perceive an intelligent system, motion detecting sensor, embedded in their home, which surround humans in their daily lives and activities and should enable them to live independently longer...(Zaad and Allouch, 2008)”</p> <p><i>Other(s):</i> (Sarkisian et al., 2003); (Goins et al., 2010)</p>  |
| Surveillance camera     | <p>“...Using surveillance cameras at seniors’ home will assist to prevent them from accident, injury, illness or other ailment that effects mobility...(Sarkisian et al., 2003)”</p>   |
| Recording device        | <p>“...Installing recording devices at seniors’ home will assist to prevent them from accident, injury, illness or other ailment that effects mobility...(Sarkisian et al., 2003)”</p>   |
| Flood alarm             | <p>“...Elderly people install flood alarm at their home to enhance quality of life and safety purposes...(Ahn et al., 2008)”</p>   |
| Telecare                | <p>“...Seniors use home telecare as an instrumental in improving independence and safety...(Peeters et al., 2012)”</p> <p><i>Other(s):</i> (Mahoney, 2010); (Huang, 2011); (Lai et al., 2010); (Walsh and Callan, 2011); (Peeters et al., 2012); (Demiris et al., 2013); (Heinz et al., 2013)</p>  |

Table 8 Technology options: smart home and remote care

We have also found that older adults have been using supportive devices for their functional ability; see Table 9. Medicine reminder, hearing assistance technologies and rehabilitation assistive devices are some examples of these devices. These devices may be more applicable for older people living at home, for example a medicine reminder may not be as useful in a residential care setting with health care professionals providing constant reminders and maybe even direct medicine dispensing to individual patients. Again these are direct assistance technologies and may not be needed as early in a patient’s life if indirect methods such as brain training through games are used to improve memory and daily living skills.

| Technology                        | Sample of Adoption  |
|-----------------------------------|---|
| Medication reminder device        | <p>“...Older adults with multiple chronic conditions face the complex task of medication management involving multiple medications of varying doses at different times. Using medication reminder devices aid older adults to manage their medications....(Reeder et al., 2013)”</p> <p><i>Other(s):</i> (Stojmenova et al., 2013); (Wong et al., 2012)</p> |
| Hearing assistance devices        | <p>“...Hearing assistance devices help elderly people hear better in order to maintain independence and enhance their quality of life...(Southall et al., 2006)’</p>  |
| Rehabilitation assistance devices | <p>“...Seniors appreciate using rehabilitation assistance devices due to benefits for mobility, confidence, safety and independence... (Smith et al., 2002)”</p> <p><i>Other(s):</i> (Mitzner et al., 2010); (Sintonen and Immonen, 2013); (Goins et al., 2010)</p>   |

Table 9 Technology options: supportive devices

### DISCUSSIONS AND OUTLOOK

The world's population is ageing rapidly and the cost of caring for older people is also rising. An important feature of population aging is the progressive aging of the older population itself. By 2050, the world will have almost 400 million people aged 80 years or older. As such, the age group of 80 and older has become the fastest growing age segment in the global population (OECD, 2012). Age is a good proxy for high support needs; 40 per cent of those currently aged 85 years and over are estimated to have a sever disability, as measured by their ability to perform their daily activities (Leeson et al., 2004). This means the group of older people with high support needs is growing, as the prevalence of some physical and cognitive conditions such as dementia and movement difficulties is popular among this group.

One approach to above mentioned concern is to maintain the older adults' abilities and skills for their everyday life for a longer period of time, which will decrease the caring costs and increase the quality of life of elderly. In this regard, technologies can play a significant role. Although the research in this matter has been growing and there have been different empirical evidences on contribution of assistive technologies for improvement of elderly's quality of life, the effective potentials of technology in maintaining seniors' abilities need further investigations. In response to the research question, “What are the potentials of assistive technologies for seniors”- we found assistive technology can provide aid for elderly, but are underutilized to offer effective training for skills that may empower seniors for independent living.

Having reviewed the literature in assistive technologies for aged care, this paper has identified two basic categories; direct supportive and indirect empowering technologies. Supportive technologies provide aid to seniors for their everyday life. A primary goal of assistive technologies is to maintain independent lifestyle of older adults. These technologies are usually designed to aid elderly for their daily life. We have found general purpose ICT, robots; online information services, smart home and remote care and supporting devices have been utilized to this end. Empowering technologies take a proactive approach to assist elderly for their independent living. These technologies highlight the fact that we need to not only aid seniors for their daily living activities, but also we should train them to improve their skills over the time. These group utilizing technologies such as games or social media provide facilities for elderly to maintain or improve their physical, cognitive or social skills.

Despite all the concerns and attempts reported in literature for independent living, less is known on the differentiation of technologies that provide direct support for seniors' daily activities and indirect support through empowering technologies that help the elderly through skills training for independent living. In this paper we consider direct supportive technologies differently to indirect, empowering technologies, for example using brain training through games to improve an older person's resilience so they become less dependent. Another example of empowering technologies is to use social media to empower seniors using internet for expand the circle of friends and avoid the social isolation issues.

The term "empowerment" is a contested notion. It is a very complex term that is difficult to define. (Silva, 1997) refers to empowerment as any process whereby people can gain increased control over their lives. (Narayan et al., 2000) further defines empowerment as any process that enables "self-confidence, self-direction, autonomy, and self-worth". For the purpose of this paper, empowerment is the process of maintaining a concrete, new capability to perform some specific action (Cornish, 2006). Here empowerment is not seen as an increase in self-confidence or control, rather the ability to take an action. Actions refer to the seniors' daily activities. This view of empowerment implies enabling seniors to develop a range of capabilities (Gigler, 2004), and refers to capability approach (Sen, 1999), that can be utilized in adoption as the process of expanding a choice that lead people to the lives they have reason to value. The implication of this approach in our study is to adopt assistive technologies that build capabilities for seniors to help themselves in their daily activities as opposed to being supported by technologies. This will lead them to maintain their independent living, which they value highly. In this respect, capability theory (Sen, 1999) confirms that technology adoption by seniors empowers them to change and improve their well-being which in turn leads to more independent living. However for adoption to be effective, empowerment of some skills is required. Using capability theory, we can conclude that for seniors to be capable to live independently we must provide them technologies that train and empower their skills related to their everyday life activities. However, as proposed by capability theory, individual, environmental and psychological factors significantly influence this adoption.

From the technology options identified earlier in this paper, we believe games and social media, because of their interactive nature, empowers elderly for their daily living. However, looking at Figure 3, we can see games and social media have been given very limited attention in the research community. We therefore encourage researchers to investigate the adoption of games to empower elderly and help maintain their skills for independent living. We also suggest that the use of capability theory can help in this endeavor.

Games offer complex scenarios that can stimulate discussion, collaboration and imagination, or train skills such as hand-eye coordination, strategic abilities and problem solving. Cognitive training is a set of procedures to help people maintain a useful level of performance in everyday tasks for different functions such as attention, memory, and reasoning, which can be also achieved by games. We believe games can provide cheap and enjoyable off-the-shelf platforms to support cognitive training. While games can empower elderly for their everyday life, physical exercises available through the game platforms e.g. Xbox Kinect can potentially support movement difficulties in older adults.

We can think of several ways that social media can empower seniors to live on their own. A common seniors' refrain is that they would like to stay in touch with their family and friends. Social media can be used as a means by which seniors can use to stay connect with their friends and family while they might suffer from movement or driving difficulties. The importance of socializing as part of a community cannot be overstated, particularly for seniors spending much of their time living isolated at home. It can be critical for those unable to get out of the house to be with others. Social media provides the opportunity to have and be a friend, to congregate without leaving the house, to never be alone even when you are the only one in the house.

The article concludes that much research has been conducted to directly support elderly in their everyday life while there are avenues of opportunities for empowering elderly and training them to maintain their abilities using assistive technologies that need to be discovered by researchers.

### LIMITATIONS

As is the case with almost any review, this paper has a few limitations that must be kept in mind and these are discussed below.

#### Quality dependency on the choice of keywords

This review, like any other literature review, is highly dependent on the keywords that have been chosen and the databases that have been selected for the search. However, in this study, we have conducted a background and exploratory search and keywords and databases were selected according to an experimental method proposed by (Dieste et al., 2009).

#### Limited resources

Because realist reviews embrace complexity and seeks to map out the operation of multiple theories in multiple contexts, they can easily grow quite large. Compared to systematic reviews, a realist review, therefore, can only cover a limited number of papers.

#### Focusing only on publication in 2000 – 2013

The resources that have been selected in this review were only papers published during 2000 and 2013. This decision was made in order to focus of the study on recent developments in the field, it is still arguable that authors may have missed valuable technologies and adoption approaches that are applicable to today's aged care settings.

#### Nature of the studies that have been reviewed

In addition to the limitations on resources for this review, there are limitations to the nature of information that could be retrieved. Most studies on the adoption of assistive technologies for aged care are not done from a realist perspective and therefore important details for a realist review about the nature of the intervention and its context may be omitted.

#### Reliability of the results

In order to ensure the reliability of the results and avoid bias, we have deployed the proportional reduction in loss (PRL) method. We asked four experts from North America, Australia, Europe and Asia to review both interventions and impacting factors of adoption. However, it is still arguable that the results might have been impacted by subjectivity of the authors as well as the judges.

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