ACIS 2013 Proceedings   Australasian (ACIS)

2013

Analysis of Research in Adoption of Assistive Technologies for Aged Care

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Abstract

The main objective of this study is to provide detailed analysis on the research conducted in the area of adoption for assistive technologies in aged care. The article analyses the studies and concludes with avenues, guidelines and gaps for research in this area. This study has conducted a systematic search on eight popular academic databases and identified relevant papers published. The paper identifies potential technologies that have been utilised to address seniors' daily life difficulties in three areas: independent living, social isolation, dementia and medication taking. The article presents the theoretical lenses used for studying the adoption of these technologies in aged care. In addition to that, the systematic review has come up with interesting demographics on research approaches, and fields of publication for the research in this area. The paper outlines that the Australian research in adoption of assistive technologies for aged care has been over focused on healthcare domain and has largely ignored information system outlets. The possible reasons and potential directions for this issue have been discussed.

Keywords

Adoption, Aged Care, Systematic Review, Assistive Technologies

INTRODUCTION

The world's population is ageing rapidly and the cost of caring for older people is also rising. For example 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). In Australia, in 2010, 13% of the population was over the age of 65 years and by 2050 this is predicted to rise to around 32% (ABS, 2010) with the greatest rate of growth in people with more than 85 years old (Soar et al., 2008). In the same time it is expected that we will face a tremendous shortage of qualified professionals in the aged care sector (WHO, 2007); (Commonwealth of Australia Productivity Commission, 2011). One solution to this problem could be the increased use of assistive technologies to provide efficiencies and lower costs, these new technologies have the potential to assist the elderly in their daily living.

Marshall, (1997) 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 customised, 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 the seniors' daily lives. Our concept 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.

The framework introduced by World Health Organization (WHO) (OECD, 2012) highlights the significant role of assistive technologies in the area of aged care. The report puts an emphasis on the adoption of technologies by seniors, which is the topic of this review.

There has been a growing body of literature in adoption of assistive technologies in aged care. However, a broad view of the research characteristics in the field is missing. It is essential to have a holistic view to work around this area, which can open new avenues of opportunities and also new perspective to the topic. This work aims to provide a demographic analysis of the studies published since 2000. Having done that, we will be able to present the strengths and weaknesses of current approaches in adoption of assistive technologies for aged care and identify gaps in the research agenda; thus enabling us to draw out possibilities and future avenues for research in the field. We also wanted to see how much of the technology research was published in information systems journals.

METHOD

The objective of this study was to conduct a review, which informs researchers, professionals and healthcare staff of the research paradigms in use with respect to technologies to assist seniors in their daily living. This study aims at providing a big picture of the existing studies in the field. As such, a systematic review approach was selected to address the research goals. For this to happen, we customised the guidelines for systematic reviews laid down by (Law et al., 1998). The review involved three steps (1) Searching for the initial list of studies, (2) Relevance appraisal, and (3) Extracting data. The following section explains the process.

Searching For the Initial List of Studies

The first step towards searching the articles was to identify the relevant keywords. This was carried out following the experimental method proposed by (Dieste et al., 2009). We have conducted a survey (Vichitvanichphong et al., 2013) on relevant papers published since 2009, in journals with impact factors more than 1 in the areas of Medical Informatics and Information Systems. In this survey, we found most relevant related keywords to "aged care" and "adoption" used with "technology" in the similar purpose to this study. The following search phrase were used while querying each database – i.e. the search indicated that the article should contain the word 'Technology' along with any of "aged care", "aged", "aging", "senior", "old", "elderly", "elder" or "older" and any of in its titles, keywords, abstract or full text.

- ("Technology") AND
- ("aged care" OR "aged" OR "aging" OR "senior" OR "old" OR "elderly" OR "elder" OR "older" OR "gerontechnology") AND
- ("adoption" OR "acceptance" OR "use" OR "behavioural intention" OR "behavioural intention" OR "attitude" OR "believe" OR "belief" OR "usefulness" OR "diffusion" OR "user")

Once the keywords were determined, 8 online databases were searched to find the initial list of the studies. In the search, titles, keywords, abstract and full text were considered and the search was limited to studies published since 2000, inclusive.
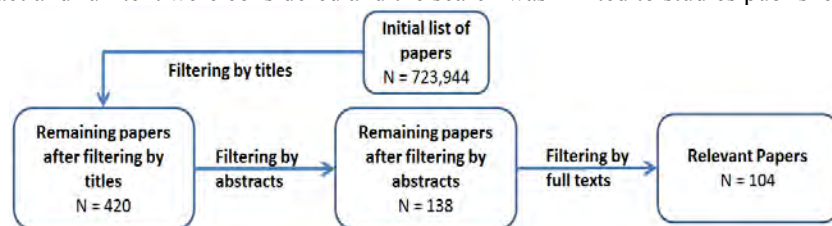

Figure 1 Search Process

The databases were searched over multiple subjects and returned total of 723,944 articles (see Figure 1). A full list of databases and number of papers in each step are reported in Table 1. We found some of the papers are indexed by multiple databases. The total number of the papers after deducting the repeated papers was 104.

Table 1 Initial List of Studies

Name of Database	Initial list of papers	Filtered by titles		Filtered by abstract		Filtered by text	
		Number of found articles	Number of repeated articles	Number of found articles	Number of repeated articles	Number of found articles	Number of repeated articles
Springer	16,539	213	22	31	11	18	6
Wiley InterScience	453,537	99	15	17	8	11	5
ScienceDirect	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
Total	**723,944**	**632**	**212**	**213**	**75**	**158**	**54**
Relevant papers by deducting the duplicated articles		**420**		**138**		**104**	

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 "Adoption of assistive technologies for aged care". This process was carried out by excluding papers based on titles, keywords, abstracts and full texts. The removed articles that have one of the following exclusion criteria:

- 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

Among 723,944 papers published in the selected journals in since 2000, 723,312 papers excluded by their titles and 723,731 articles by their abstracts and 723,786 papers by their full texts. 104 relevant papers remained after this process.

Extracting and Analysis of Data

In the data extraction stage, key details from the selected papers were obtained. In this review, the information extracted was divided into seven groups; (1) the year of publication, (2) technologies that have been used by seniors, (3) the problems that have been solved by these technologies, (4) the theories that have been applied to explain the adoption (5) application areas, (6) research approaches, and (7) geographical area of data collection.

Following the guidelines provided for realist review (Law et al., 1998), and applied in several studies such as (Bakhshi et al, 2013; Talaei-Khoei et al , 2012), we have chosen a heuristic iterative approach to analyse the extracted data. Given that the realist review seeks to analyse data in social contexts of an intervention, it is important to find out reported evidence. Therefore, this analysis method has been selected according to its proven efficacy in categorizing extracted data for complicated social contexts (Law et al., 1998).

RESULTS

In following, we present the demographic characteristics of the research in adoption of assistive technologies for aged care.

Theories

Figure 2 illustrates that most of the papers in adoption of assistive technologies for aged care have not used any theories to frame the research or explain their results. This demonstrates the need for more attention to be paid with respect to theoretical support for the studies and to improve the reliability of the results. Of the papers that do use a theory, the major theories used are the technology Adoption model, Diffusion of Technology, and Unified Theory of Acceptance and Use of Technology. We suggest further investigations in other theories than these three popular ones, as some of the other theories listed in Figure 2 have shown initial effectiveness in the adoption of assistive technologies for aged care.

Figure 2 Theories

Fields of Publication

We found Information Systems with 53 studies and Healthcare with 46 articles as most active communities in the research related to the adoption of assistive technologies for aged care. However, authors have shown very limited interest for publication of related topics in Computer Science, Management and Education outlets. Figure 3 presents the distribution papers fields.

Figure 3 illustrates that academics publish their research results on adoption of assistive technologies for aged care equally in journals related to the fields of Information Systems and Healthcare, while very much less so in the field of Computer Science. This could be due to two reasons; (a) Computer scientists generally deal with building technologies while most of articles were trying to use off-the-shelf technologies, (b) Adoption is not a typical topic of interest in computer science

journals. Surprisingly, we have found very few papers in Management journals. This can be due to the technology element and user perspective involved in the topic. We have also found one paper in Education.

Application Areas

We have found that the studies have targeted three main problems in aged care: (a) independent living, (b) mental health, and (c) medication taking. However, some of the papers have used the technologies for multiple applications. The greatest attention was paid to assisting elderly to continue their independent living in their own homes. For many, the thought of having to move to aged care residential settings appears to be a big incentive to adopt technologies that may allow them to stay in their own home a bit longer. Some of technologies have addressed the isolation issue and the application of technologies such as social media to help reduce loneliness among seniors. Some other studies deployed technologies to improve memory performance of elderly and to help reduce the effects of dementia. The last two categories have been classified as assisting people in the mental health area. Reminding seniors to take the right medicine at the right time has been a major contribution of technologies in this area. Figure 4 presents the applications of technology in aged care.
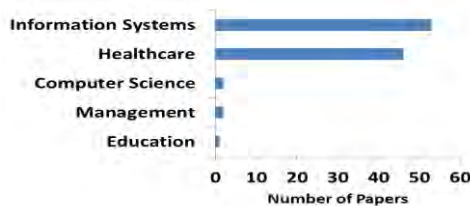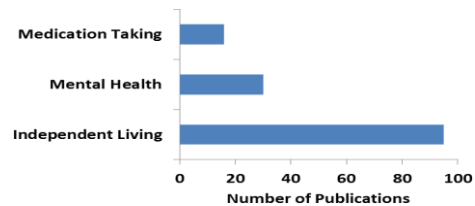

Figure 3 Fields of Publication   Figure 4 Application Areas

Technology Options

As seen in table 2, we have categorised technologies that have been adopted in relevant papers into eight categories. The first category is *ICT in general purpose* which 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. The second category is *social media* in order to stay in touch with people, establish social networks, gain information and even share thoughts and experiences. Another category is *games*; either video games or mobile games. Older adults have been using games as a therapy tool, entertainment, relaxation and socialisation. *Robots* also have been found as one of well-known technology options in this research. The social robots have been used in health-related settings such as seniors' domestic environments. Research has found that for seniors to adopt robots in their daily lives, building long term relationship with the robots is necessary. 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 *Smart home* category is also used to help seniors balance safety and independence through remote monitoring, motion detecting sensors and flood alarms technology. Furthermore, *remote care or 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. We have also found that older adults have been using supportive devices, for example, medicine reminder services, hearing assistance technology and rehabilitation assistive devices, etc. in order to improve their functional ability.

Year of Publication

This section provides the statistical trend of literature on adoption of assistive technologies among seniors. Figure 5 presents the distribution of the relevant articles per year. The trend line illustrates an increasing interest from the academic community in the topic in particular after 2009.

Figure 5 suggests that the adoption of assistive technologies for aged care has caught the attention of researchers as a major concern in healthcare. Despite annual fluctuations in the number of publications, the overall trend is strongly positive and this illustrates the increasing interest in this field. This interest is reflected in the research which is increasingly outlining innovative approaches in the aged care setting and the potential application of technologies to assist seniors.

Online Databases

The present literature review has studied the eight databases. After the relevance appraisal step, a total number of 104 papers were considered; while 54 articles were repeated in different databases (see Figure 6).
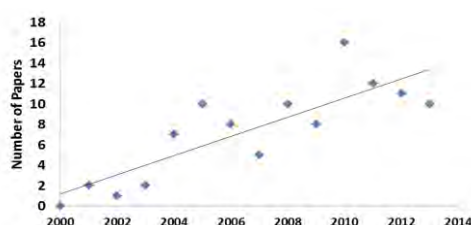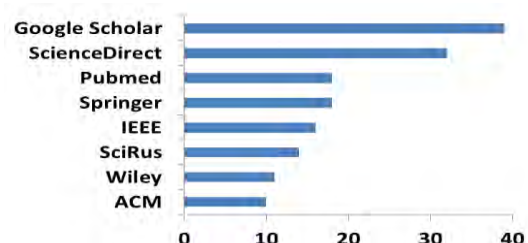

Figure 5 Year of Publication   Figure 6 Online Databases

We have found that Google Scholar is the most popular database to search for articles relevant to the topic of "adoption for assistive technologies in aged care". This can be due to the inclusion of many academic journals in Google Scholar. Surprisingly, Science Direct had more relevant papers than PubMed. Having taken a closer look at the papers, we found this is due to the multi-disciplinary nature of the research in the field of adoption of assistive technologies among seniors. While PubMed indexes the healthcare specific journals; Science Direct searches outlets from different disciplines, although the number of indexed journals is much less than PubMed. For the same reason the IEEE and ACM databases contained very few relevant articles. Springer, SciRus and Wiley, due to the smaller numbers of indexed journals came up with very limited numbers of relevant articles. In summary, we found Google Scholar, Science Direct and PubMed as the most relevant databases for this topic.

Table 2 Technology Options

Technology Option	Technology
General Purpose ICT	**_Email_** (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) **_Mobile phone/ Smart phone_** (Conci et al., 2009) (Guo et al., 2013); (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); **_Digital camera_** (Salovaara et al., 2010) **_MP3_** (Salovaara et al., 2010) **_GPS_** (Salovaara et al., 2010) **_PDA_** (Wilkowska and Ziefle, 2009) **_Computer_** (Aula, 2005); (Cameron et al., 2001); (Ahn et al., 2008); (Mitzner et al., 2010); (Selwyn, 2004); (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) **_Internet_** (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) **_Video conference_** (Beer and Takayama, 2011); (Wong et al., 2012); (Or et al., 2011); (Bickmore et al., 2005a); (Selwyn et al., 2003)
Social Media	**_Online social networks_** (Braun, 2013); (Heinz et al., 2013) **_Online community_** (Chung et al., 2010); (Ryu et al., 2009); (Wong et al., 2012)
Games	**_Video games_** (Laver et al., 2011); (McKay and Maki, 2010); (McLaughlin et al., 2012); (Heinz et al., 2013); (Wood et al., 2005) **_Mobile games_** (Chu Yew Yee et al., 2010)
Robots	**_Interactive Social Software_** (Heerink et al., 2010); (Bickmore et al., 2005b) **_Social robot_** (Klamer and Ben Allouch, 2010); (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)
Online Information Service	**_Online health service_** (Heinz et al., 2013) **_Electronic Health Records_** (Price et al., 2013) **_eService_** (Phang et al., 2006); (McCloskey, 2006) **_Online learning_** (Chu, 2010)
Smart Home	**_Remote monitoring_** (DEMIRIS et al., 2004); (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., 2009); (Ahn et al., 2008); (Steele et al., 2006) **_Motion detecting sensors_** (Zaad and Allouch, 2008); (Sarkisian et al., 2003); (Goins et al., 2010) **_Video camera_** (Sarkisian et al., 2003) **_Recording devices_** (Sarkisian et al., 2003) **_Flood alarm_** (Ahn et al., 2008)
Remote Care	**_Telecare_** (Mahoney, 2010); (Huang, 2011); (Lai et al., 2010); (Peeters et al., 2012); (Walsh and Callan, 2011); (Peeters et al., 2012); (Demiris et al., 2013); (Heinz et al., 2013)
Supportive Devices	**_Medicine reminder devices_** (Stojmenova et al., 2013); (Reeder et al., 2013); (Wong et al., 2012) **_Hearing assistance technology_** (Southall et al., 2006) **_Rehabilitation assistive devices_** (Smith et al., 2002); (Mitzner et al., 2010); (Sintonen and Immonen, 2013)

Research Approaches

We found 36 studies that have adopted a qualitative research approach and 53 papers that have used qualitative methods. Fifteen papers used a mixed methods approach; see Figure 7. It appeared that research in this field mainly focuses on end user characteristics and cause-effect relationships that is why quantitative methods are very popular in this field. However,

we believe that uncovering underlying motivations for seniors to use technologies, understanding different individuals' perspectives among elderly to adopt technologies, and comparison of what older adults feel about a particular technology in a context are required. Discovering these aspects in adoptions of assistive technologies for aged care, authors might choose to benefits the qualitative research.
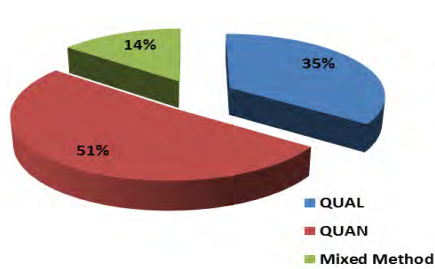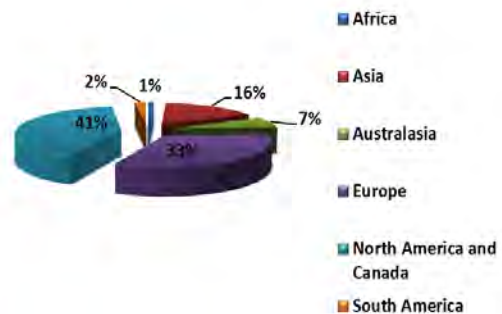

Figure 7 Research Approaches

Figure 8 Geographical Distribution of Studies

Geographical Distribution of Studies

Most of the adoption of technologies for aged care research has been conducted in North America, Canada and Europe. There were other studies conducted in Australasia and Asia but very little in Africa and South America, see Figure 8.

Figure 9 shows that research results on the adoption of assistive technologies in North America and are published equally in information systems and healthcare journal outlets, while Asian researchers focus more on information systems. The research output around the topic in Australasia is published entirely in healthcare. The numbers were too small to report for the Africa and South American regions.

Figure 10 shows that in North America, Europe and Australasia, the different research methods have got fairly similar attention. While in Asia quantitative methods are more popular. Due to the small number of studies in Africa and South America, we have removed them from this comparative graph. This could be due to researchers in Asia being more comfortable with quantitative analysis and a reluctance to write and report qualitative rich data in English publications as English is not popular in Asia. We suggest that Asian researcher pay more attention in qualitative methods to benefits the advantages in particular contexts.
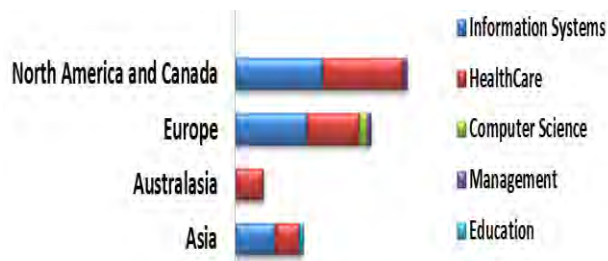

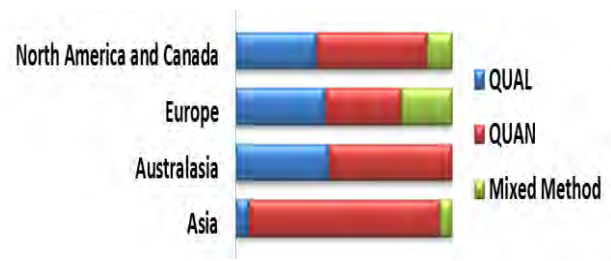Figure 9 Fields of Publication in different Geographical Places

Figure 10 Distribution of Research Approaches in different Geographical Area

CONCLUSIONS AND FUTURE WORK

Adoption of assistive technologies in aged care is a dynamic research area and our review of the literature has indicated that interest in this research area is increasing. Although we admit that the increase in the number of papers in adoption of assistive technologies for aged care might have happened because of the general increase in the number of publications, we refer to the applications of these technologies in real settings that have been analysed through realist review. The review has identified eight technology options that are being researched. Research in each of these areas is at different levels of maturity and the theoretical framework adopted and the research paradigm used will naturally differ accordingly. However we suggest that a generalised analysis of demographic factors in this area of research is useful as it can provide some guidance with respect to the technology options that could be researched in the future and it can also provide details of possible gaps in the research. This work serves as a good starting point for further research in this specific, important field of IT innovation for aged care. A patient cantered approach, encompassing factors such as policy, economy and technology is suggested. The discussion that follows is based on the results shown in this paper and our interpretation of the current state of research into assistive technologies in aged care and the gaps as we see them.

With respect to publication outlets, around half the research in North America, Europe and Asia were published in information systems journals, yet virtually none were published in information systems journals from Australian academics.

This could be a reflection on the different emphasis Australian scholars place on the research. The emphasis and publications seem to relate more to healthcare than information systems. This difference in publication outlets can lead to some questions that could have some relevance to the information systems discipline in Australia. For example; does the predominance of publications in healthcare journals mean that academics in Australia relate this research topic more strongly to healthcare than information systems or does it mean that Australian information systems academics do not research in this area? Another possibility for Australia being "out of step" with the rest of the world could be the excellence in research (ERA) push for quality publications and the "pigeon holing" of academics into set journals. Another interesting link to this could be the fact that a significant number of papers have no theory associated with this type of research (see Figure 2). Does this (in the eyes of Australian IS academics) preclude publications in IS journals because the discipline is so insistent in having a solid theoretical base for all papers published?

From this study we conclude that there is a lot of research conducted in the area of developing innovative technologies in independent living, however the other two areas of mental health and medication taking appear to not be as extensively researched, although we suggest that they are of equal importance for the health and wellbeing of older people. It would therefore seem that there is a research gap in this area and there are opportunities for researchers work in the area of assistive technologies in mental health and medication taking.

The lack of a theoretical framework for many research studies is assumed to be problematic and we strongly recommend further research to deploy other theories in this area. In addition and as a corollary to the lack of a theoretical framework is the lack of qualitative research, particularly in Asia. The nature of the assistive technology and the characteristics of the target population would suggest that a rich insight as to why technology is or is not adopted is needed. We suggest that qualitative approaches can provide more information with respect to the nuances and context of particular problems in this area; we therefore encourage researchers to adopt more qualitative approaches in understanding the process of adoption of assistive technologies among seniors. Perhaps this should be directed more to our Asian colleagues as qualitative research in the Asian region is particularly scant.

The researchers have found a significant implication in this review based on the results from the literature. Referring to the technology options, which have been regularly used by seniors, they can be categorised into two groups: Empowering technologies and supportive technologies. Even though there has been a growing body of literature in the use of assistive technologies for aged care, 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 to help them with independent living. The assistive technologies can be considered as direct supportive technologies or indirect empowering technologies which would be helpful for researchers and practitioners to narrow down the needs and acquire utmost benefits to aid older adults what they exactly need.

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