Adoption of Assistive Technologies for Aged Care:
A Realist Review of Recent Studies

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Abstract

Objective: The main objective of this study is to identify the technologies that have recently been applied in aged care, the problems that these technologies have sought to address and the adoption approaches that have been taken.

Method: This paper has conducted a realist review on studies published in information systems and medical informatics journals in the past five years on adoption of assistive technologies among seniors.

Results: We have identified potential technologies that have been utilized to address seniors' daily life difficulties in three areas: independent living, social isolation, dementia and medication taking. We have also extracted the theoretical lenses used for studying the adoption of these technologies and available empirical evidences for the theories.

Conclusion: Having put the findings of this review together, we have identified factors impacting adoption of technologies among elderly. These have been classified as factors related to technologies, allocated tasks, individuals and social influences.

1. Introduction

In 2012, the percentage of the world population who are more than 65 was 6.9%, and this is estimated to increase to around 20% by 2050 [1]. This has created a growing need for innovative approaches to deliver care services for older adults. Therefore, assistive technologies for the elderly have attracted a great deal of attention in the aged care sector. There are number of definitions for assistive technologies in aged care. In 1997, Marshal [2] 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". Following to this definition in the UK, the Royal Commission on Long Term Care [3] has defined assistive technologies as "an umbrella term for any device or system that allows an individual to perform a task they would otherwise be unable to do or increases the ease and safety with which the task can be performed". The above definitions have an obvious emphasize on disabilities in seniors. A more recent definition has been given by the Australian Dementia Resources Guide in 2008 [4]. 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.

In recent years, there is an increasing necessity for technologies that can assist the elderly in their daily living. There are two main arguments for this. First, seniors traditionally like to live independently and preferably in their own homes [5], [6]. Second, it is commonly believed that the healthcare system, particularly aged care section, will soon face a huge

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shortage in qualified carers [7]. In addition, in remote and regional areas, even basic healthcare services requires patients to travel long distances to get treatment and this is further exacerbated as the elderly often suffer from movement issues and cannot drive. 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 [8].

The framework introduced by World Health Organization (WHO) [9] highlights the significant role of assistive technologies in the area of aged care. The report puts an emphasis on the acceptance of technology by seniors.

In response to the above mentioned concerns, this paper aims to look at the recent technologies that have been used for aged care and identify the approaches taken to adopt the technology from a seniors' perspective. Therefore, researchers and practitioners will be aware of the challenges in this area. This paper seeks to answer the following research questions:

- **RQ1:** What technologies have recently been used to assist seniors in their daily living?
- **RQ2:** Which aspects of seniors' daily life can be assisted by these technologies?
- **RQ3:** Which adoption theories best fit for accepting assistive technology by seniors?
- **RQ4:** What are evidences for these theories, which impact on adoption of assistive technologies among seniors?

Having answered to these questions, we will be able to inform professionals in aged care about the available technologies and the problems that can be addressed by these technologies. We will be also able to recommend healthcare providers in aged care settings for the factors that should be taken into account when prescribing seniors on using a technology in daily life.

To answer the mentioned questions, the present research has taken a realist review approach [10].

The rest of this paper is organized in the following way: Section 2 presents the method of review. Section 3 presents the findings and Section 4 discusses on the findings, limitations of this review, and recommends new avenues of research in the field.

2. Method

The objective of this study was to conduct a review, which informs researchers, professionals and healthcare staff of recent technologies, that has been used to assist seniors in their daily living. This review also looks at adoption approaches that have been recently examined as effective use of assistive technologies among the elderly. For this to happen, we customized the guidelines for realist reviews laid down by Pawson et al [10] and applied in several reviews such as [11], [12]. The realist approach has been proven [13] as an effective way of reviewing complex intervention with social aspects such as the matter of technology adoption among seniors. The realist review proposes four steps to carry out a literature review; (1) Searching for the initial list of studies, (2) Relevance appraisal, (3) Extracting data, and (4) Analysis of data. In following, we explain the process.

2.1 Searching for the Initial list of Studies

In order to identify the search resources, two topic areas have been targeted; Medical Informatics and Information Systems. These areas have been selected due to focus of this review to the adoption of assistive of technologies in aged care. An initial list of journals has been chosen from the journal classification list proposed by Excellence in Research for Australia (ERA) [14]. The relevant journals were chosen and the journals with an impact factor of less than one were omitted. This figure of below one was arbitrary but deemed necessary as some form of filtering needed to be implemented due to resource constraints. This is aligned with guidelines of realist reviews for quality filtering of identified papers [10]. The list of the journals that the search has been conducted is presented in

Table 1.
The total number of papers published in 2009 – 2013 (both inclusive) was 3611. The distribution of the papers per journals has been presented in

Table 1.

2.2 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. This removed articles that have one of the following exclusion criteria:

- Did not focus on assistive technologies for aged care
- Discussed only the technologies, not their adoption
- 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

Table 1 List of Journals

Journal	Impact Factor	Field	Articles Published 2009 - 2013	Relevant Articles
Journal of Medical Internet Research	4.7	Medical Informatics	545	5
International Journal of Medical Informatics	2.49	Medical Informatics	466	6
BMC Medical Informatics and Decision Making	1.48	Medical Informatics	395	2
International Journal of Technology Assessment in Health Care	1.36	Medical Informatics	341	1
Information Systems	1.46	Information Systems	298	2
Information Systems Journal	2.06	Information Systems	94	1
Information Systems Research	2.14	Information Systems	35	1
MIS Quarterly	4.44	Information Systems	196	1
Communications of the Association for Information Systems	1.12	Information Systems	244	2
Information Technology and People	1.21	Information Systems	214	4
International Journal of Human-Computer Studies	1.17	Information Systems	365	2
Human–Computer Interaction	2.39	Information Systems	57	2
Journal of Computer Information Systems	1.1	Information systems	124	1
Information Systems Frontiers	1.21	Information systems	237	1
Total			3611	**31**

Among 3611 papers published in the selected journals in 2009 - 2013, 2079 papers excluded by their titles and 1493 articles by their abstracts and 8 papers by their full texts. Thirty-one relevant papers remained after this process.

2.3 Extracting Data

In the data extraction stage, key details from the selected papers were obtained. In this review, the information extracted was divided into five groups; (1) technologies for use by seniors that have been reported in the papers, (2) The problems that have been solved by these technologies, (3) The adoption theories that have been used (4) Evidence of how these theories have been proven in the studies to be significant factors in impacting on the adoption of assistive technologies among seniors, and (5) Demographics of the published works i.e. year of publication, geographical area of data collection for the study reported in the article, and the research method.

2.4 Analysis of Data

The main objective of analysis stage was to answer the four research questions that have been mentioned in the Section 1. Therefore, the following synthesizes were conducted.

2.4.1 Identifying the technology options

In order to answer the research question 1, we used the process proposed by Ghapanchi & Aurum [15]. 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 1.

2.4.2 Identifying the application areas

In order to answer the research question 2, a similar process was carried out. First, the terms and definitions of how the technologies can assist seniors were studied. A primary list of application areas was created and then the list was refined by further studies to the final application areas.

2.4.3 Articulating the adoption theories

The realism approach believes that what makes an intervention work is not how many times we observe that it works; rather it depends on what theoretical logic used and whether the intervention was successful or unsuccessful. Therefore, by changing the context, we will be still able to configure a successful deployment of the intervention [10] based on the theory. Therefore, it is essential to articulate the body of working theories that lie behind the intervention.

Hence, in order to answer research question 3, we collected prevailing theories that are reported in the final list of papers to explain how the assistive technologies was supposed to be effectively accepted by seniors – and why things went wrong.

2.4.4 Identifying the evidences impacting on adoption

Given that the realist review seeks to find out the application of theories in social context of an intervention, it is important to find out different reported evidences of deploying the theories.

Thus, a similar approach to Figure 1 was taken to identify the list of factors impacting the adoption of assistive technologies among seniors, as empirical evidence of articulated theories.
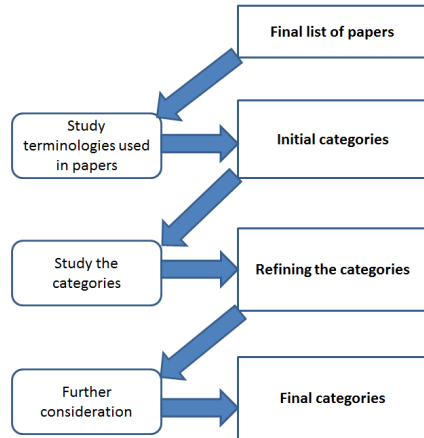

Figure 1 Data Analysis Process for RQ1, 2, and 4

3. Results

In this section, we present what we obtained from the data analysis; Technology options, application area, level of adoption, and demographics.

3.1 Technology Options
This study has categorized the different technologies that have been adopted in aged care to (1) general purpose Information and Communication Technologies (ICT) e.g. mobile, email, etc., (2) social media, (3) games, (4) online information services, and (5) smart home. Table 2 presents which technology has recently been implemented in the daily life of seniors.

Table 2 Technology Options

Type	Technology
General purpose ICT	Electronic Mail [16][17][18]
	Virtual reality [19]
	Mobile Phone [16], [20]
	Internet [16][21][22][23][18][24][25]
	MP3 Player [26]
	GPS [26]
	Computer [21][25]
Social Media	Blogs [27]
	Internet-based social Networks [28]
Games	Video Games [29][30][31][32]
	Learning Games [33]
	Mobile games [34]
Online	Mobile health services [35][36]

Information Services	Health records [37][38][39]
	Online training [40]
Smart Home	Remote monitoring [41][42][43][44][45][46]

We found that general purpose ICT has gotten more attention than other technologies where despite the potentials and recent advancements of in social media, applications of this technology have been largely ignored in aged care, See Figure 2.
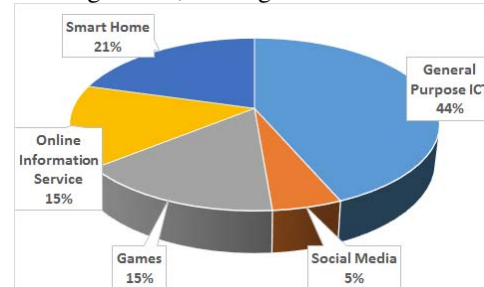

Figure 2 Distribution of Technology options

3.2 Application Areas
The study has also identified that the technologies have been used to address the three different aspects of seniors' daily living (described above), namely; (1) independent living for seniors, (2) mental health of older adults i.e. dementia and social isolation, and (3) Medication taking for seniors. Table 3 presents the application areas and the technologies that have been used in these areas.

3.3 Adoption
In this section, we present the theoretical perspectives and empirical evidences in the relevant studies.

3.3.1 Technology adoption theories
Having reviewed the final list of papers, Theory of Reasoned Action (TRA), Diffusion of Innovation Theory (DOI), Theory of Planned Behaviors (TPB), The Unified Theory of Acceptance and Use of Technology (UTAUT), Technology Acceptance Model (TAM), and Socio-Technical System Theory have been found to be used as theoretical backgrounds to the adoption of assistive technologies among seniors. Table 4 presents the theories and their key constructs impacting on adoption.

3.3.2 Evidences and influencing factors
After identifying the theories that have recently been used to explain adoption of technologies among seniors, we looked for the evidence of adoption. The list of variables measured for each influencing constructs of the theories was identified. Also, it was determined whether a variable has been reported with a significant impact or not. It was found that some of the influencing factors have not been studied in the

relevant papers that we examined. It was also revealed that there have been conflicting reports on the significance of some of the variables (see Table 4). Later in Section 4, we will recommend future work on the impact of these variables.

Table 3 Application areas and Technologies

| Application Area		Technology Type	Technology
Independent living		General purpose ICT	Electronic Mail [16][18]
			Internet [16][21][23][18] [25]
			Computers [21][25]
			Mobile Phone [16]
			GPS [26]
		Games	Video Games [29][30][31][32]
		Online Information Services	Mobile health services [35][36]
			Health records [37][38][39]
			Online training [40]
		Smart Home	Remote monitoring [42][43][44][45][46]
Mental Health	Dementia	General purpose ICT	Virtual reality [19]
			Internet [22][24]
			MP3 Player [26]
		Games	Learning Games [33]
	Social isolation	General purpose ICT	Electronic Mail [17]
			Mobile Phones Mobile Phone [20]
		Social Media	Blogs [27]
			Internet-based social Networks [28]
Medication Taking		Smart Home	Remote monitoring [41]

3.4 Demographics

In this section, we look at field of publication, research method and geographical areas of studies.

3.4.1 Field of publication
We found 14 studies in four medical informatics journals and 17 articles in ten information systems journals. Therefore, topic of adoption of assistive technologies among seniors has found more attractive
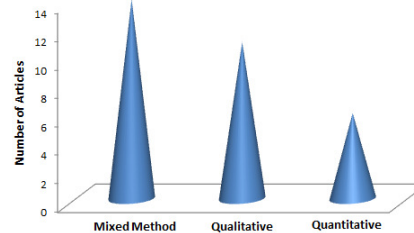
in healthcare related outlets than Information systems journals (see Figure 3).
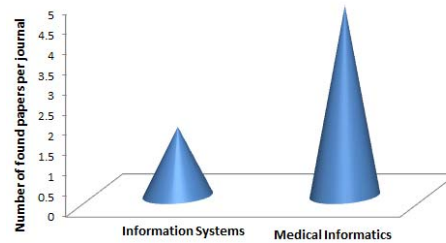
Figure 3 Information Systems versus Medical Informatics

3.4.2 Research method
We found 14 studies have adopted mixed method while 11 papers used qualitative and 6 articles quantitative methods (see Figure 4).

Figure 4 Qualitative, Qualitative and Mixed Method Studies

3.4.3 Geographical distribution of studies
We found most of studies have been conducted in North America and also considerable number of them in Europe. Asia and Asia-Pacific had respectively only three and one studies among 31 papers. We could not find any study conducted in the Middle East or Africa.

4. Discussion and Conclusions

The present work has applied realist review method to gain insight of the literature on adoption of assistive technologies in aged care. Therefore, the study looks at adoption approaches in relation to their context [10], which requires attention in two main perspectives; (1) what has been counted as assistive technology and (2) how it has been adopted.

The first perspective has driven the review to define the context in terms of the technologies that have been used to help elderly and the daily problems that these technologies have tried to solve. The present paper has come up with five different categories of information technologies that have been utilized in this area: General purpose ICT, Social Media, Games, Online Information Services, and Smart Home. Table 2 shows the examples of these types of technologies that have been identified in the final list of papers studied in this work. However, these examples can only be considered as proofs of concepts for applicability of the

technology types for aged care and certainly do not claim to limit technical interventions.

Table 4 Theories, Influencing Constructs and Evidences

Theory	Influencing Construct	Measured Variables in the Article	Significant Impact?	
			Yes	No
Theory of Reasoned Action (TRA)	Attitude toward Behavior	Level of confidence to the use of technology	[43][41][16]	
	Subjective norm	Opinions from families and friends	[16] [35] [43]	
		Opinions of nurses in aged care settings	[29][33][28][30][32][26]	
Diffusion of Innovation Theory (DOI)	Compatibility	Compatibility with the life style	[35]	
		Compatibility with the seniors' needs	[41]	
		Compatibility with the seniors' values	[46]	
	Complexity	Complexity in the skills required to use the technology	[37][39][18]	[41]
		Complexity in the user interface	[29]	[31]
	Relative Advantage	It has not been found.		
Theory of Planned Behaviors (TPB)	Attitude toward behaviour	Seniors value what the technologies assist them to do.	[42]	
	Subjective norm	Making the technology available in the daily social gatherings at aged care settings		[31]
	Perceived behavioural control	Seniors' perception of their dedication to the use of the technology	[40]	
The Unified Theory of Acceptance and Use of Technology (UTAUT)	Performance expectancy	It has not been found.		
	Effort expectancy	The effort that the technology needs to get outcomes.		[27]
	Social influence	Other close friends use a similar technology.	[21]	
		Perception of seniors on others' reactions about them, using the technology.	[27]	
	Facilitating conditions	It has not been studied.		
Technology Acceptance Model (TAM)	Perceived usefulness	How much the technology can improve their difficult conditions?	[21][40]	
		How much other friends have been beneficial from a similar technology?	[22]	
		How much can seniors feel the improvements at very early stage of using the technology?	[40][32]	
	Perceived ease of use	Confident about using the technology.	[17][25][21][40][24][32]	
		Easy to read instructions.		[23][22]
Socio-Technical System Theory	People	Gender	[27][38][19]	[20]
		Technical Experience	[20]	
		Education	[27][30][17]	
	Technology	Appearance		[27]
		Skills needed	[38]	
		Price	[44]	[36][45]
	Tasks	It has not been found.		

In terms of the problems that have been solved by technologies, this study has identified independent living, mental health; i.e. social isolation and dementia, and medication taking as the areas that have brought the attention of technical innovations.

Figure 2 shows that the research in assistive technologies for aged care has paid the greatest attention to general purpose ICT. We believe that this is because the research in each of the application areas can benefit from these interventions, not to say that cost, availability and general knowledge for these technologies have significantly contributed in their advantages and applications. However, it should be considered that the technologies in the general purpose ICT option suffer from the lack of advanced functionalities required for more effective interventions. Therefore, we encourage researchers for more tempts in adoption of other types of technologies. While most of technologies in Table 2 are assisting elderly for their daily living, games because of their interactive nature have potentials to improve seniors' skills that would be useful in their daily living. This advantage of games comparing to the other technology options can open avenues of opportunities for proactive research towards independent living of elderly. Of disadvantages of games, we can think of difficulties of their adoption and safety issues. More studies and improvements in these two areas are required. Smart homes and online information services can be considered as two different approaches to remote care; by remote monitoring or by providing information. However, both of these two technologies suffer from the cost of implementation and services. Social media have been recently developed intensively in our everyday life; however seniors have not been exposed to the potentials of these technologies. One advantage of social media for elderly can be expanding their social networks and develops the circle of their friends. This can impact on their motivation to participate in social events. However, authors believe that extensive research on adoption of social media among seniors and factors impacting for successful acceptance of these technologies is required.

As far as adoption of assistive technologies among seniors is concerned, the realist review presented in this paper has identified six theoretical perspectives in the studied papers: Theory of Reasoned Action (TRA), Diffusion of Innovation Theory (DOI), Theory of Planned Behaviors (TPB), The Unified Theory of Acceptance and Use of Technology (UTAUT), Technology Acceptance Model (TAM), and Socio-Technical System Theory. Then, it has sought to find supporting evidences for applicability of these theories in the final list of the papers. Table 4 presents the list of the theories, their constructs and the evidences collected from the studies. However, we have found some of the variables impacting on adoption of assistive technologies among seniors have been repeated in different studies. Therefore, following the analysis method explained in Figure 1, we have

summarized the factors in four different groups: factors related to technology, social influences, individual characteristics, and the tasks that technologies have been used for (see

Figure 5). Technology related factors look at the compatibility of technologies with lifestyle, seniors' needs and their values. Social influences highlight the role of social interactions that seniors have with their family, friends and even their nurses and emphasize the impact of these interactions on elderly's acceptance of assistive technologies. Individual related factors look at demographic differences between seniors and their perceptions of using technologies. Task related factors evaluate the impact of differences in the nature of the problems that the assistive technologies try to solve on seniors' acceptance of these technologies. However, some of the constructs of the theories in Table 4 have not been found in the papers, similar factors could be identified in evidence associated with other theories. In addition, some of the factors have been observed in some studies with significant impact and in some other studies with not significant impact. Therefore, we have put these into a group which we recommend researchers for further studies.

4.1 Future Work

4.1.1 Conflicting results in some influencing factors
It has been noted that little evidence has been reported in some studies as factors with a significant impact while other studies have indicated them as not influential. Therefore,

Figure 5 has put them in one box and presents them as factors that require further study.

These factors include the price of technology, complexity of the technology (i.e. in terms of skills required to use the technology and user interface) and the gender of seniors. We encourage researchers to conduct further studies to find out if these factors have significant impact on adoption of assistive technology among seniors.

4.2 Limitations
As is the case with almost any review, this paper has a few limitations that must be kept in mind.

4.2.1 Limited resources
Because realist reviews embrace complexity and seek to map out the operation of multiple theories in multiple contexts, they can easily grow quite large. Comparing to systematic reviews, a realist review, therefore, can only cover a limited number of papers. In this paper, key journals, with impact factors more than one, have been selected as primary outlet for quality studies. This is aligned with guidelines of

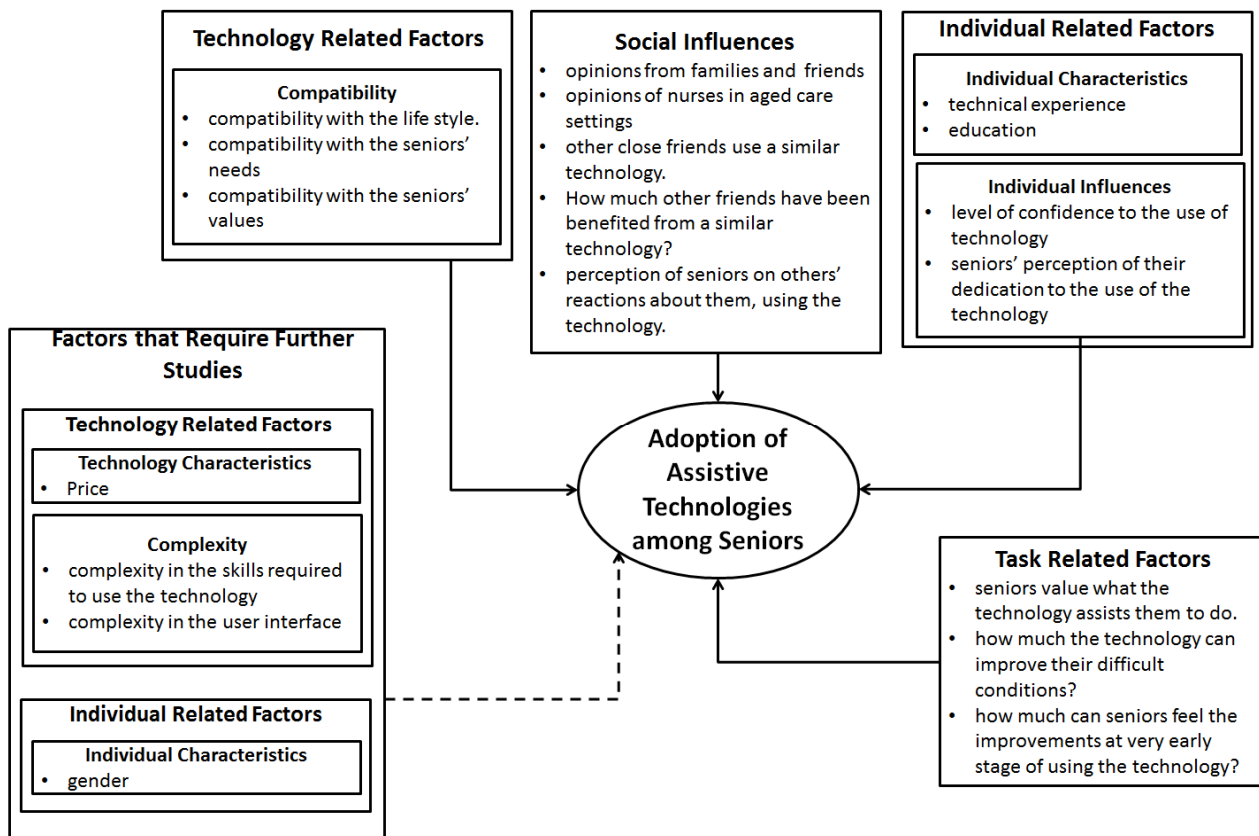realist reviews for quality filtering of identified papers   [10].

Technology Related Factors

Compatibility
- compatibility with the life style.
- compatibility with the seniors' needs
- compatibility with the seniors' values

Social Influences
- opinions from families and friends
- opinions of nurses in aged care settings
- other close friends use a similar technology.
- How much other friends have been benefited from a similar technology?
- perception of seniors on others' reactions about them, using the technology.

Individual Related Factors

Individual Characteristics
- technical experience
- education

Individual Influences
- level of confidence to the use of technology
- seniors' perception of their dedication to the use of the technology

Factors that Require Further Studies

Technology Related Factors

Technology Characteristics
- Price

Complexity
- complexity in the skills required to use the technology
- complexity in the user interface

Individual Related Factors

Individual Characteristics
- gender

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Task Related Factors
- seniors value what the technology assists them to do.
- how much the technology can improve their difficult conditions?
- how much can seniors feel the improvements at very early stage of using the technology?

Figure 5 Factors impacting adoption of assistive technologies among seniors

4.2.2 Focusing only on publications in 2009 - 2013

The resources that have been selected in this review were only papers published during 2009 and 2013. However, this has decided due to the 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.

4.2.3 Nature of papers that have been studied in this review.

In addition to the limitations on resources for this review, there are limitations to the nature of information that could be retrieved. Most studies of 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.

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