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Innovation and technology for the elderly: Systematic literature review☆

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ABSTRACT

As life expectancy increases, so does the number of elders. This increase poses a challenge regarding the ability of maintaining the costs for providing services to this group. In search of solution, practitioners have found technology to improve the life style of the elderly and reducing the costs in long term. This demographic change leads to opportunities for disruptive innovation as well. Elders' acceptance of innovative technology in their everyday life is a success key factor for the governments, technology providers, healthcare providers, and other major players in elders' life. This study systematically reviews the existing literature and identifies the actors in elders' life. In addition, the study provides a comprehensive review of elder's innovative technology adoption, including the impacts and costs. The study also offers suggestions and guidelines for future research.

1. Introduction

We witness global demographic change phenomena in a way that population is rapidly aging. Population of elderly is growing twice as fast as the growth of the whole population (United Nations, 2009). The estimation of United Nations reveals that aging rate is 2.6% per year (United Nations, 2009). This trend of aging leads to tremendous increase of costs of elderly care.

Many countries strive to deal with the increasing number of service requirements for the elderly. Improving elders' lifestyle quality on one hand and decreasing the costs of healthcare and services on the other hand are the challenges of many organs in the government. For instance, United States has the most expensive health care in the world, and the costs for elderly care are increasing tremendously (Rahtz & Sirgy, 2000). The United Nations named Japan as the first super aging country in 2007 (Iwasaki, 2013).

Rooting technological innovation into elders' everyday life and home care is an answer to prevent elders' dependence and support their independence (Iwasaki, 2013). Palumbo et al. (2014) explain that home-assisting technologies are entering the market and they are moving from the research and development stage to mass production. In England, the Republic of Ireland, Sweden and Portugal, ongoing projects exist such as ACTION (Assisting Carers using Telematics Interventions to meet Older people's Needs) (Magnusson & Hanson, 2003). Cooper and Cronin (2000) discuss the competitive strategy for long-term care industry in United States. In Japan, Iwasaki (2013) emphasizes the role of technology tools in elders' life. In Italy a study identifies details regarding an up-to-date technology innovation design specifically for the elderly (Lattanzio et al., 2014).

Kohlbacher and Hang (2011) express that the market of elderly is an excellent field of disruptive innovation application, since the elders' demand for new, just-good-enough, easy to use, and affordable products and services increases tremendously.

Despite researchers' consideration of technology tools for the elderly since the 1980s (Gilly & Zeithaml, 1985) and the investments and endeavor from responsible organs, Skymne, Dahlin-Ivanoff, Claesson, and Eklund (2012), who qualitatively examine elders' attitudes toward assistive technology, reveals that the elderly do not believe that employing technology tools results in a meaningfully improved life quality. Iwasaki (2013) asserts that the elderly has not integrated with the information society yet. Thus, the elderly is not prepared to fully adopt technology tools (Heart & Kalderon, 2013; Ott, 2016). In 2015, the study of Nikou emphasizes that research on the elderly and use of technology tools is in the early stages (Nikou, 2015). Melkas (2011) emphasizes that there are many actors in innovation adoption processes and practitioners usually disregard the important role of each one of the actors. Thus, deep comprehensions encompassing factors impede and diffusion of elders' innovative technology tools adoption is crucial.

This study focuses on identifying the major actors in elders' lives and the impacts and costs of elders' innovative technology adoption by reviewing and synthesizing the existing research. Technology tools, in this study, refer to all electrical, technical and mechanical means that improves the everyday life of elderly in any area of housing, communication, healthcare, and education. The study strives to map the academic

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research on this subject within different disciplines, specifically in Sweden. The aim is not only to understand what researchers have done but also to identify research gaps and provide suggestions for future studies.

Sweden has several special features that make this country very relevant for this study. First, population grows very old. Sweden is the second European country for having the largest proportion of people with age of 80 or more (5.3% of the total population; Swedish Institute, 2015). Second, the European Innovation Scoreboards project for the European Commission (2015) reveals that Sweden has been the most innovative country in Europe since 2007. This fact shows the robustness and reliability of infrastructures in the country.

Following this introductory section, Section 2 illustrates the method for selecting articles for an extensive literature review. Section 3 discusses major actors in elders' life. Latterly, this section presents the conceptual framework for assessing the impacts and costs of elder's technology tools adoption. Finally, Section 4 explains conclusions and suggests future research directions.

2. Method

The goal was to locate academic research focusing on the elderly and technology tools in Sweden. For the search, the study used the electronic database EBSCO using the following keywords *computer assisted*, *technology*, *telehealth*, *monitoring*, and *elderly*. Furthermore, the search focused only on academic and peer-reviewed journals. To focus on very current research, the search centered in 2010–2015 texts. Using all the criteria, the results show 1,139,512 studies. Adding Sweden to keywords reduced the results to 216. After screening the title of articles, 36 articles remained. Of these studies, only 18 remained after abstract analysis. In detail, one study was not in natural environment; eight articles had no health-enabling technologies; four studies did not focus on elders and five studies were not in Sweden at all. Table 1 illustrates the list of journals that published the chosen articles.

3. Major actors in elder's life

The major processes in technology tools adoption are: acquisition process; introduction and orientation process; information and communication process; and service and monitoring process (Melkas, 2013). Adoption of technology involves many actors and it is significantly related to skills and knowledge of individual users and professional groups, which practitioners usually give little attention to this fact (Melkas, 2011).

The literature review suggests the following major actors in this context: elderly (E) themselves, their family (F), healthcare providers (HP), technology providers (TP), and Government and policy makers (G). The following sections describe each actor and their role in elders' life. At the end, Table 2 depicts how the literature in Swedish context considers these actors along with technology type, and Table 3 illustrates assessing impacts and costs of elder's technology tools adoption.

Table 1
List of journals.

Name of journal	Number of articles located (n = 18)
Aging and mental health	1
Aging and society	1
BMC medical informatics and decision making	1
Computational intelligence	1
Disability and rehabilitation: assistive technology	2
Gerontologist	2
Health care analysis	1
Journal of technology in human services	2
Nursing inquiry	1
Proceedings of the Estonian Academy of Sciences	1
Scandinavian journal of caring sciences	1
Scandinavian journal of occupational therapy	1
Sensors	1
Technology and disability	2

3.1. Elderly

There are many positive impacts of using technology tools for the elderly such as improving their life quality and enables them to live more independently at their homes. The technology tools may also improve the elders' health status; for instance, the elderly can follow some daily exercises from the tablets. The Internet is a window to the world; therefore, elders who use the Internet have many advantages over those who do not.

The other aspect is integration with the information society. The communication technology tools such as tablets empower the elderly to be more involved in their family and friends' lives through reading their blogs, for instance. Eek and Wressle (2011) reveal that to be part of society, individuals need to use different technology tools. The elderly may face social isolation when they have problems using technology, since active participation in society for them depends on well-functioning means of communication.

The elderly will use technology tools if the technology is *affordable* (being able to buy and maintain the technology), *accessible* (information and services about the technology are available), and *usable* (ease of use, the usage does not lead to feelings of stress and confusion) (Iwasaki, 2013). In addition the literature identifies age and education as significant factors for elders' technology tool adoption (Berner et al., 2012; Galindo-Martín, Méndez-Picazo, & Castaño-Martínez, 2016).

Several researchers have investigated elders' technology acceptance and adoption, for instance Renaud and van Biljon (2008) develop STAM, which stands for Senior Technology Acceptance Model.

Existing literature identifies numerous barriers for the elderly using technology tools, which is possible to categorize them to elders' physical and mental status. The barriers due to impairments of elders' physical status are cognitive (memory and processing speed; Czaja et al., 2006; Eek & Wressle, 2011; LeRouge, Ma, Sneha, & Tolle, 2013), visual, auditory, and motor control abilities (Eek & Wressle, 2011; LeRouge et al., 2013). The mental barriers are attitudinal (manner of feeling or behaving; Ellis & Allaire, 1999; Skymne et al., 2012), privacy concerns, security (Harrefors et al., 2010), safety (monitoring elderly in their private home; Boström et al., 2013; Caine, Fisk, & Rogers, 2006; Miskelly, 2001; Magnusson & Hanson, 2003; Petersson et al., 2012), and total replacement of humans with technology tools such as robots (Kristoffersson et al., 2011; Lundberg, 2014).

Focusing on the methodology of recent studies in Sweden, it is clear that the majority consider the elders' attitude toward innovation and technology tools. For instance, Kristoffersson et al. (2011) measure with a 5-point Likert scale elders' attitude toward emerging technologies and how these attitudes change over time. This study does not use a specific method or theory. Frennert et al. (2013) use Rogers (2010) diffusion of innovations theory for content analysis of the interviews before and after the experiment with GiraffPlus. Boström et al. (2013) measures elder's attitude drawing on five focus-group interviews with discussion on *freedom* and *surveillance* as content areas. Freedom focuses on the results of technology use, and the concept of surveillance involves something that controls the elderly (Boström et al., 2013). Cesta et al.'s (2011) study, using a single-item measure with eight different scenarios, reveals that the elderly have a significantly positive opinion on usefulness and acceptability of artificial intelligence systems. These robots remind elders about their medications, finding objects, etc.

3.2. Family

The support from family and relatives is very important for the elderly to adopt technology or not. Especially now that Sweden has changed

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Table 2
Map of major actors and technology for elderly among the recent peer-reviewed articles in Sweden.

	Major actors					Technology for elderly						
Study	E	F	HP	TP	GP	W	G	DM	ACTION	BLN	AT	
Kristoffersson, Coradeschi, Loutfi, and Severinson-Eklundh (2011)	X		X				X					
Hanson, Magnusson, and Sennemark (2011)	X	X	X		X				X	X		
Gund, Lindecrantz, Schaufelberger, Patel, and Sjöqvist (2012)			X					X				
Wälivaara et al. (2011)			X					X				
Nordgren (2012)				X		X						
Cudd, Magnusson, and Hanson (2012)	X	X	X						X			
Skymne et al. (2012)	X						X					
Frennert, Forsberg, and Östlund (2013)	X						X					
Boström, Kjellström, and Björklund (2013)	X							X				
Berner, Rennemark, Jogréus, and Berglund (2012)	X											Internet usage
Harrefors, Axelsson, and Sävenstedt (2010)	X										X	
Petersson, Lilja, and Borell (2012)	X											Feeling safe
Lundberg (2014)		X									X	
Palumbo et al. (2014)	X			X			X					
Jämsä, Kangas, Vikman, Nyberg, and Korpelainen (2014)				X				X				
Kangas, Korpelainen, Vikman, Nyberg, and Jämsä (2015)				X				X				
Cesta et al. (2011)				X				X				
Eek and Wressle (2011)	X					X						

Note. In major actors E: Elderly, F: Family, HP: Health provider, TP: Technology provider, and GP: Government and policy makers. In technology for elderly W: Websites, G: Giraffe, DM: Distance monitoring, BLN: Blended Learning Networks, and AT: Assistive Technology.

their policies from giving welfare to the elderly toward a model building on partnership in which government and family mutually share the responsibility of taking care of the elderly (Hanson et al., 2011). In this regard, Hanson et al. (2011) describe an innovative practice to enable elders, healthcare providers, and their family to learn together, exchange knowledge, and support each other in local development work. This community communication practice Blended Learning Networks (BLNs; Hanson et al., 2011).

The elders' use of technology has impacts on their family as well. For instance, with the use of communication technologies families will be more involved in the elders' lives, with less travel back and forth to them.

3.3. Healthcare providers

In the project Giraffe, healthcare providers can virtually visit elders via a mobile-teleoperated robot and conduct a normal visit (Kristoffersson et al., 2011). The nurses acting as teacher in the experiment show a very positive attitude toward and acceptance of technology, although elders react in very different ways (Kristoffersson et al., 2011). Healthcare providers have many suggestions for improving services and technology tools for the elderly (Hanson et al., 2011).

Gund et al. (2012) measure the attitude of healthcare providers toward technology by monitoring of a known disease in 17 counties in Sweden. They reveal that the majority of participants (approximately 74% of 139) have a positive attitude. Sixty-six percent of these professionals are nurses, 30% physicians, and 4% others. In addition, the study measures their opinion on the possibilities for technologies as a tool in future healthcare and their confidence in technology as a tool in healthcare. Nurses show more positive attitude than physicians do. Gund et al. (2012) use single-item measures for each concept without using any theories to support these measures.

Despite all the positive attitudes from healthcare providers, Wälivaara, Andersson, and Axelsson (2011) asks for caution: Technology should not replace visits and telephone calls. In addition, technology is not applicable to all cases.

Table 3
Assessing impacts and costs of elders' technology tool adoption.
Adapted from Melkas (2013)).

	Impacts and costs of elders' technology tools adoption				
	The elderly	The family	Healthcare providers	Technology providers	Government
Impacts	Improvement of life quality (e.g., more daily exercise and more entertainment)	More possibilities to involve in the elders' lives via communication technology tools	Improvement of services to the elderly	New opportunities (new market)	New challenges
	More independent life		Improvement in monitoring the elders' health status	New designs for specific needs of elderly	Decrease of home care operators
	More opportunities for interaction with family and friends		Changes in work contents	Disruptive innovation	Increase in well-being
	More social activity involvements		Time for other tasks		Better monitoring of home care operators
	May have less privacy				
	May have more security				
Costs	Purchasing costs	Less travel costs	Less travel costs	New product development costs	Costs of monitoring the processes
	Using costs		Decrease of staff costs		
	Maintenance costs		Training costs		
	Training and education costs		Purchasing costs		
			Using costs		
			Maintenance costs		

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3.4. Technology providers

This demographic change of increasing the number of elderly who is in good health and active can be seen as a new market for many industries. The specific features for the market of elderly, that Kohlbacher and Hang (2011) call as *silver market*, can be listed as: low income; resistant to changes; and late innovation technology tool adopters (Gilly & Zeithaml, 1985). Kohlbacher and Hang (2011) with the use of disruptive innovation framework reveal that elders' market is the exceptional field of application for disruptive innovation, low-end disruptions and new market disruptions, since the elders' specific demands for products and services increased as has never been done before.

Technologies such as credit cards, which elders deal with every day, are the necessary ones for them. In addition, other technologies could improve their independence, safety, and reduce the costs in comparison to traditional methods. Some examples of these technology tools are: Giraff (a mobile-teleoperated robot; (Kristoffersson et al., 2011); Health body® (distance monitoring; automated fall-detection; Wang, Zhang, Li, Lee, & Sherratt, 2014); and automated emergency detection.

The studies involving technology providers specifically in Sweden focus mainly on technical aspects such as study of Palumbo et al. (2014) that tests distance monitoring and assisted living technologies in real environment and provide details on their technical design and programs. Cesta et al. (2011) investigate the aspects of an artificial intelligence system that monitors elders at home. Jämsä et al. (2014) focus only on falling detection algorithms. Falling detectors can call for help in the case of emergency and save lives; this way, they facilitate elder's independence and allow them to feel more secure at home. Because one of the aging problems is decreasing motoric control, falling is a serious problem for this group. In this regard, Kangas et al. (2015) investigate false alarms and the sensitivity of the falling detector systems by monitoring 16 elders. Results show that the systems have 80% sensitivity.

One recent study in Sweden very briefly touches new product development for the elderly. That is the study of Kristoffersson et al. (2011), which shows that involving the elderly in the design process and development of new technology tools determines their acceptance and use of these technology tools later on.

From a marketing point of view the study of Nordgren (2012) examines the website of 25 technology providers and concludes that two major values exist, which these firms emphasize. First, technology tools allow providing services such as telehealth and health monitoring, which would decrease the number of home visits. Second, the results of using technology tools allow having a better life quality. Nordgren (2012) argues that these technology providers should narrow their target down and do not generalize these values to all elders, because some might prefer human interaction and might value social time with a health provider rather than being more independent by using technology tools. He suggests that using technology in a particular context is better than not using very advanced technology at all.

3.5. Government and policy makers

In Sweden the municipalities have the responsibility of the elderly care; however, the elderly can choose a private or public operator (Swedish Institute, 2015). Since 1980s the healthcare for the elderly has decreased due to their better health situations (Swedish Institute, 2015). In 2013, private operators provided 24% of total elders' home care (Swedish Institute, 2015).

In 2014 the costs of elderly care is EURO 11.7 billion; the private sector covers only 4% of costs (Swedish Institute, 2015). Twenty percent of total population (i.e., 9.8 million) is 65 years old or older and the life expectancy is 79.9 years for Swedish gentlemen and 83.7 years for Swedish ladies. (Swedish Institute, 2015).

The Swedish citizens can choose to receive national retirement pension between the ages of 61 and 67, the average amount of pension in 2014 is EUR 1198.82 (Swedish Institute, 2015). The number of elderly who work between ages of 65–74 has increased 127% from 2005 to 2014 (Swedish Institute, 2015).

The Swedish government prognoses that in 2040 one out of four Swedes will be over 65 years old, in a good health and activity level (Swedish Institute, 2015). Thus, government has suggested increasing the retirement age, as one solution for future challenges (Swedish Institute, 2015).

Hanson et al. (2011) are the only ones in recent years in Sweden to include politicians in their study. The results show that politicians speed up the decision-making process by giving direct feedback to their political committees.

In summary, Table 2 maps the academic literature on elders' use of technology in Sweden. It clearly depicts the research gap from involving government and technology providers' perspectives. Table 3 is adapted from the study of Melkas (2013) to Swedish context and has more components based on this literature review. Table 3 shows the items for assessing the impacts and costs of elder's use of technology. Although cost-effectiveness is crucial, there are not any studies in Sweden addressing it. This theme is very sensitive and extra considerations should be devoted on ethical questions.

4. Conclusions

The literature review reveals several important facts about technology tools and elders in Sweden. First, the majority of the studies on elders build on observations, focus groups, and interviews, which shows that the research within this domain is in its infancy and that this field needs more research. As technology tools for the elderly move from research phase into commercialization, both conceptual and empirical research are still scarce (Kohlbacher & Hang, 2011).

Second, studies measure elder's attitude toward technology mainly through interviews or single-item variables, many well-established theories exist on measuring attitudes.

Third, the studies in this literature review come from researchers of areas such as health care, rehabilitation, the elderly, or from web-designers and program developers. None of the publications comes from the business and economics fields, revealing that this field lacks the business perspective. Melkas (2013) explains that adoption of technology is a multi-disciplinary and complex process and that its success depends on technology application, costs and marketing (Melkas, 2013). Literature identifies significant factors of development of technological innovation for the elderly, which are: technology innovation, marketing innovation and social, organizational, and process innovation (Melkas, 2011). Currently, there are very limited studies on application of well-grounded and established theories from the fields of innovation and technology management (Kohlbacher & Hang, 2011), marketing management and consumer behavior.

Finally, this literature review shows that different definitions exist for elders. The elderly is a very diverse group that includes senior citizens over 55-year-old with diverse characteristics, behaviors, and needs. Some studies have compared the young-elderly with elderly and have shown differences within this group (cf. Gilly & Zeithaml, 1985).

The conclusion section suggests several research trends. The first trend is *investigating the elder's technology adoption within different age groups*. The second trend is *empirical assessment of impacts and costs of elders' technology adoption*. Finally, the third trend is *evaluating the disruptive innovation of elders' market*.

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