Acceptance of health-related ICT among elderly people living in the community: A systematic review of qualitative evidence

Lars Tore Vassli, Trondheim Municipality,
Trondheim, Norway, Lars.Tore.Vassli@trondheim.kommune.no

Babak Farshchian, Stiftelsen SINTEF
Trondheim, Norway, Babak.Farshchian@sintef.no

Abstract

There is a growing number of seniors and a growing need for health-related ICT (Information and Communication Technology) solutions to allow seniors live independently in their own homes and communities. We need to have a better understanding of how and why seniors use or do not use health-related ICT in such settings so we can improve our solutions. In order to synthesise existing knowledge we did a systematic literature review using Scopus and PubMed. We searched for both review articles and primary qualitative studies. 11 review articles and 31 primary research articles were included in the study. We structured our findings using the UTAUT2 acceptance model developed by Venkatesh et al. Our findings show that seniors want health-related ICT that gives them independence, safety and security, allows them to socialize, manage their own health, and helps them in their daily activities. They need to easily get help if they have problems using services, get tailored training and help during use. Lack of privacy and safety, and stigma are some of the reported barriers. Health-related ICT at home is different than both consumer and institutional ICT. We need more research in order to develop a specialized and operationalized acceptance model for health-related ICT use among seniors. Our mapping to UTAUT2 is a step in this direction, and suggests a possible specialization of this model.

Keywords: *Technology acceptance; older adults; seniors; assistive technology; health ICT; community-dwelling; UTAUT2; UTAUT; TAM*

1. Introduction

Western populations are undergoing radical demographic changes. The proportional number of elderly citizens in many countries is increasing because of increased life expectancy and reduced birth rates. By 2050, the number of people aged 60 or above is expected to more than double, and the number of people over 80 is expected to triple, compared to 2015 (United Nations, 2015). These demographic changes have profound consequences. Healthcare systems are already under pressure because of the prevalence of non-communicable diseases, increased expectations from the citizens, and the large variety of costly interventions that are in demand. As we age, our needs for healthcare and wellbeing services also increase. We need innovative solutions that will allow us to restructure our healthcare systems and think differently about how we will provide healthcare services in the future.

One of the structural changes within healthcare services has been to move health- and care-related duties out of hospitals and into community and home. This is in particular true of elderly people and people with chronic diseases. Studies have shown that elderly people want to live in their own home or

residence of choice for as long as possible, thus maintaining their independence (DeJonge, Taler, & Boling, 2009). By enabling the elderly to stay safe in the community for a as long as possible, the society as a whole also benefits economically, as there is less need to increase capacity in nursing homes and institutions (Mostashari, 2011).

One way to accomplish this "aging in place" is to utilize innovative technologies in order to empower elderly who would have otherwise needed support from healthcare personnel. For instance, fitness-related technologies could be used to keep elderly physically fit, and postpone the need for healthcare services. Self-management tools could be used to allow elderly people with chronic diseases to measure and react to health data. Sensors could be used to automatically monitor health conditions and dispatch help in emergency cases. Large public initiatives, such as the Active and Assisted Living (AAL) research program funded by the European Union, are trying to apply ICT (Information and Communication Technology) solutions to address these and other application areas.

One of the challenges of using innovative ICT solutions to assist elderly to live independently is related to the elderly users' motivation to use, and acceptance of the solutions. The current generation of older adults are often not affluent users of technologies such as wearables and social computing. We can assume that this situation will change in the near future, as baby boomers seem to value mobile data services (Yang & Jolly, 2008). However, there are aspects of aging that will anyhow affect older adults' ability and motivation to use ICT. No matter how motivated or trained an elderly person is, physiological and biomechanical changes that are a natural part of the aging process will put limitations on the use of technology (Farshchian & Dahl, 2015). For instance, although mobile devices are becoming the *de facto* entry point for many online services, several studies show that older adults can have difficulties when entering text on mobile devices (Zhou, Rau, & Salvendy, 2014) or when performing pointing and targeted touching on touch-screen mobile devices (Hwangbo, Yoon, Jin, Han, & Ji, 2013). As another example, older adults might have different interaction habits and limitations than younger users when navigating web pages and performing tasks in online portals—activities that are now a days required by many public and private service providers (Romano Bergstrom, Olmsted-Hawala, & Jans, 2013). Moreover, the underlying values held by elderly can be different from those of healthcare providers (Dahl, et al., 2015). This might apply to e.g. time required to learn to use a system, privacy, and perceived benefit.

Our understanding of the parameters that influence ICT acceptance among elderly is still limited. Generic acceptance models—such as the UTAUT2 model (Venkatesh, Thong, & Xu, 2012) referred to in this article—do not teach us much about the specific aspects of ICT acceptance among elderly. A few specialized usability and acceptance models relate to specific technologies, for instance website evaluation (Lynch, Schwerha, & Johanson, 2013) or Internet literacy and experience (Yu & Chao, 2014). A number of systematic reviews of literature exist –we provide an overview in the next section. However, the majority of these reviews focus on impact analysis. They tell us what works or not, but say little about why or how some technologies are accepted or rejected by elderly. There is an emerging literature of qualitative studies of ICT acceptance among elderly—the focus of our research—which is not available to researchers in a synthesized form.

Our research question is: *What empirical evidence from qualitative research do we have regarding the acceptance of health-related ICT among elderly people living in the community?* To address this question we have conducted a systematic review of literature. As a theoretical framework for analysing and representing our results we have used the UTAUT2 (Unified Theory of Acceptance and Use of Technology 2) model of technology acceptance, devised by Venkatesh et al. (2012). This is an extension of the original UTAUT model (Venkatesh, Morris, Davis, & Davis, 2003), which described acceptance and use of technology in an organizational context. UTAUT2 extends UTAUT to the consumer context. The UTAUT2 model is illustrated in *Figure 1* below. We believe this model provides a suitable framework for structuring our findings. It is widely used, is easy to understand, and is itself based on a large body of empirical research conducted by numerous researchers.

However, although according to the model age is a modifying parameter for acceptance of ICT, UTAUT2 does not go into details of what this implies. We aim to identify mechanisms that affect the constructs identified in UTAUT2 applied to older adults living in the community and using health-related ICT. This is similar to the mechanisms presented in the proposed extension of UTAUT2 in a healthcare context by Slade et al. (Slade, Williams, & Dwivedi, 2013), but focused on older adults living in the community.

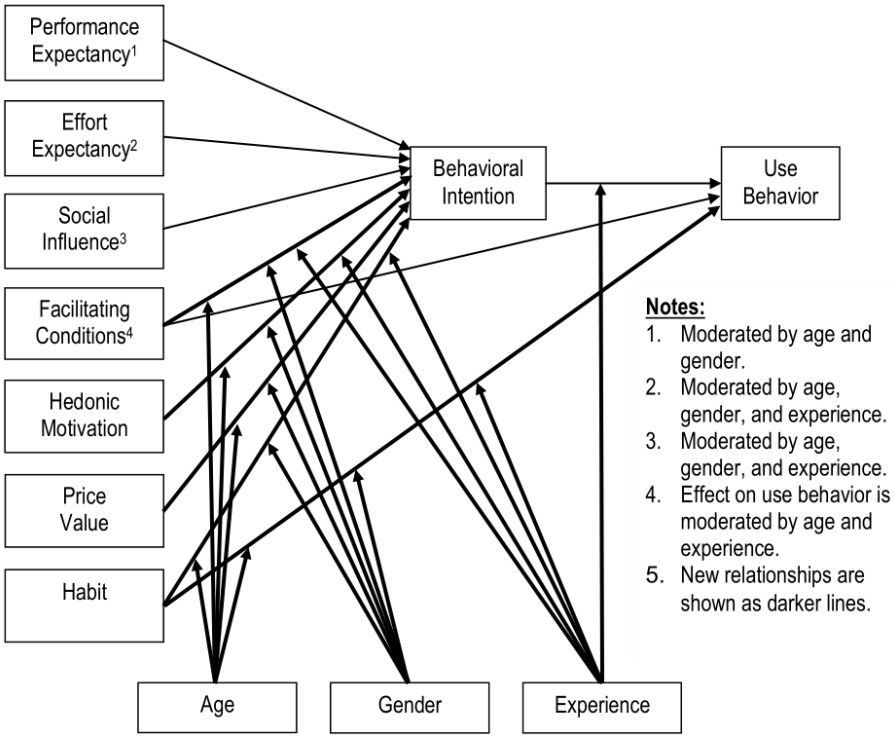

Figure 1: UTAUT2 Model (Venkatesh, Thong, & Xu, 2012)

The rest of this paper is organized as follows. In the next section we will provide a motivation for why our review is needed and what it adds to existing knowledge. We will then describe the method we have used to conduct the review. Our findings from the literature are then presented. This is followed by a discussion of the findings.

2. The need for this review

Doing health-related research with elderly is costly, especially when we want to involve them in design and development processes. It is therefore important to reuse prior research results as often and as much as possible. These research results provide an initial framework that can be useful for the designers of health-related ICT in order to make their initial designs more relevant. The importance of such knowledge is reflected in the large number of literature reviews in this field that have emerged in the recent years.

The question then comes to mind: why a new literature review. We also asked the same question before conducting our review. As we will show later, our review consists of two parts. One is a short analysis of existing reviews (secondary studies), and one is the main review of the primary studies. We analysed 11 existing reviews in order to find out how well they addressed our research question, and whether there was a need for a new review.

We found that the majority of existing reviews are impact-oriented. They address the question of what works and what does not work but provide little knowledge about why and how. This limitation of the

systematic review method is also recognised by other researchers (Dixon-Woods, 2006) and qualitative methods have been proposed as a complementary approach (Wolfswinkel, Furtmueller, & Wilderom, 2011). Acceptance of technology is a topic where the *why* and *how* questions are important. In order to address this gap, our review does two things. First, we include only primary studies that use qualitative methods to investigate ICT acceptance. We include only articles where the elderly themselves are source of qualitative data. Second, we use a mixed method approach to analyse these studies. In addition to the standard quantitative coding process, where articles are coded with an a priori coding scheme in order to classify them, we use a second level qualitative coding based on the grounded theory approach (Wolfswinkel, Furtmueller, & Wilderom, 2011). This means that we have read and coded the findings in all the included studies, allowing the topics to emerge from the text in the articles. This is evident from the number of quotations we have included in the text.

In addition, existing reviews seldom attempt to build theory. They often start with clear research questions, but do not investigate causal relations among their findings. This makes it difficult for practitioners to use the results in other similar contexts. Theories—when they are simple and understandable—are invaluable as design and evaluation tools for practitioners. A widely known example of such a theory is the family of technology acceptance models developed over the years by Viswanath Venkatesh and others (Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012). In our paper, we use UTAUT2—shown in Figure 1—as a framework for representing our findings. It is important to emphasize that we have not used the UTAUT2 model as a framework to analyze our data, but only as a tool to synthesize our findings from the initial grounded analysis. Our results show indication of how the UTAUT2 model can be specialized for our domain of study, though more research is needed in order to verify the suggested specialization.

Studies focusing on the voices of older adults living independently in the community constitute an emerging field that needs more research. Living with ICT at home brings with it a host of unique challenges and opportunities, different than those of seniors living in e.g. nursing homes or staying at the hospital. For instance, privacy might be a much smaller concern during a stay at the hospital but become a major concern at home. Or, we know that social networks and the co-creation of care are important aspects of care at home –compared to that in nursing homes –and need to be taken into consideration when designing ICT for community-based care (Procter, et al., 2014). Not paying enough attention to such unique requirements and needs when designing such systems can easily lead to an "extitutionalization" of home, turning home into an institution (Milligan, Roberts, & Mort, 2011).

3. Review Method

Our review consists of two main parts: first we conducted a review of existing literature reviews on the topic (secondary sources), and then we looked into primary sources. Both parts used the same databases and search string.

We have followed the main steps defined for systematic reviews in software engineering (Kitchenham & Charters, 2007), which are 1) definition of research questions, 2) definition of search phrases and inclusion and exclusion criteria, 3) search and retrieval of sources, 4) data extraction and analysis, and 5) data synthesis. During the definition of the research question, we have additionally identified a candidate model (UTAUT 2). We use this model for synthesizing and representing the findings during the synthesis phase. As mentioned above, during data analysis and extraction we employ a mixed-method approach, using both quantitative and qualitative coding. The additional qualitative step is performed only for the primary studies and not for the review papers.

3.1. Data sources and search strategy

We constructed the research questions and the inclusion and exclusion criteria through several iterations. We developed several versions of the search string, studied the results from search engines,

and refined the search string. *Table 1* in the Appendix shows the final version of the keywords that made up the search string for this study. It consists of five columns. We first created sub-searches joining all the keywords in each column using the OR logical operator. The results from each sub-search were then joined with other columns using the AND logical operator (except the *Exclusion* category, which used AND NOT).

We used the Scopus and PubMed databases to search for relevant articles. Scopus is the largest online database of academic literature, and covers most major journals in the field of information systems and computer science. PubMed is the largest online database of medical and healthcare publications. We had no date limitation in our search. The Scopus search gave 745 hits, and we got 112 hits in PubMed. The further process of screening is illustrated in *Figure 2* in the Appendix.

3.1.1. Literature reviews (secondary sources)

We used the feature of the search engines that allows the user to limit searches to literature reviews (available in both Scopus and PubMed). This gave us n=100 hits in total (Scopus n=77 and PubMed n=23). The results were then merged and duplicates were removed, leaving n=85 review articles. The first author then reviewed the remaining articles and screened these using the inclusion and exclusion criteria presented below. After the screening phase, n=75 articles were excluded because they did not match the inclusion/exclusion criteria, or we did not gain access to the full text of the article. This left us with n=11 review articles, see *Table 4* in the Appendix for an overview of the included reviews.

3.1.2. Primary sources

For the primary sources (initially n=767, see *Figure 2* in the Appendix) we started by merging the results from both databases, and then removing duplicates (both with an automatic tool—EndNote bibliography software—and manually). We were then left with n=731 articles. Next, each author independently screened the articles by reading their abstracts and deciding whether they were relevant to our research question and matched our inclusion/exclusion criteria. The articles that were excluded by one author but not the other were then reviewed once more until we had a consensus about included articles. The total number of included articles after screening was n=105. Of these, n=16 were excluded because we could not find the full text article[1], leaving us with n=81 articles. After a top-down coding of these articles—coding for type of methodology, type of ICT, sample properties etc. – see (Vassli & Farshchian, 2016) for detailed data—we categorised n=31 articles as qualitative, n=43 as quantitative, and n=7 as mixed method. Only the qualitative research is analysed further in this article[2].

For the n=31 qualitative articles we performed a grounded theory analysis (Wolfswinkel, Furtmueller, & Wilderom, 2011). We analysed the text in these articles, looking for emerging categories of barriers and facilitating factors for ICT acceptance. During this process, we did not use UTAUT 2 nor other theories, allowing categories to emerge directly from the text. We present and discuss these emerging categories later in the article.

3.2. What was included and excluded

Table 2 in the Appendix shows the inclusion and exclusion criteria for the review of secondary sources (literature reviews). *Table 3* in the Appendix shows the criteria for the primary sources.

Table 4 in the Appendix lists the included literature reviews, and shows how these reviews differ from this one, by classifying each review in several categories. These categories are as follows:

[1] We searched only online, and did not attempt to order paper copies of these articles.
[2] We did not exclude quantitative studies during the initial screening because our future work includes a comparative analysis of the different methodologies. This comparison is not part of the current article.

- **Focus on elderly:** whether the review focuses on the elderly population.
- **Focus on ICT:** whether the review focuses on ICT-related interventions.
- **Focus on acceptance of ICT:** whether the review focuses on the user acceptance of a specific ICT intervention.
- **Reviews data collected from elderly people:** whether the papers reviewed collected data from elderly people. A "no" here could for instance mean that the review only looked at papers about the technological aspects of an ICT intervention, without collecting data from the potential end users. Or that the paper looked at the opinion of professional caregivers.
- **Looks at the general use of ICT in healthcare:** whether the review investigates the use of ICT in healthcare in general, not a specific intervention. For instance, a review about ICT interventions specifically related to fall detection has a too narrow scope.
- **Looks at ICT in general:** whether the review investigates all kinds of ICTs, not a specific type of ICT. For instance, a review limited to monitoring technology has a too narrow scope.
- **Systematic literature review:** whether the literature review was done systematically. A "no" here could still mean that it is a thorough literature review, but it might for instance not include a well-documented search process.

Table 4 also shows that our review has a larger and more general scope than the previous reviews on this topic. The most similar one to our review is Jimison et al. (2008), but it differs in that it investigates interactive consumer health IT, while this review encompasses all types of health-related ICT. Additionally, our review includes almost a decade of more recent literature.

4. Findings

In this section we present our findings from the included studies (*Table 5* in the Appendix shows an overview of all the included studies). We first shortly presents some of the findings from the secondary sources. The main part of the findings is from the primary studies, presented next in order of frequency of evidence found. Once the findings are presented, we will discuss in Sections 4.3 and 4.4 how we have used the UTAUT2 model to structure the findings. Readers who are not interested in the details of the findings from each study can skip to Sections 4.3 and 4.4, which summarize the findings while mapping them to UTAUT2 constructs.

4.1. Findings from secondary sources

The reviews have identified and discussed several barriers for technology acceptance among community-dwelling elderly, including issues with *privacy* (Fischer, David, Crotty, Dierks, & Safran, 2014; Memon, Wagner, Pedersen, Beevi, & Hansen, 2014; Pietrzak, Cotea, & Pullman, 2014), *usability/ease of use* (Wagner, Basran, & Dal Bello-Haas, 2012; Memon, Wagner, Pedersen, Beevi, & Hansen, 2014; Jimison, et al., 2008; Pietrzak, Cotea, & Pullman, 2014; Finkelstein, et al., 2012; Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd, 2014), *reliability* (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014; Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd, 2014), *data presentation accuracy* (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014), *cost of technology ownership* (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014; Finkelstein, et al., 2012), *security* (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014), *obtrusiveness* (Wagner, Basran, & Dal Bello-Haas, 2012; Chaudhuri, Thompson, & Demiris, 2014), *social stigma* (Wagner, Basran, & Dal Bello-Haas, 2012), *familiarity with technology* (Fischer, David, Crotty, Dierks, & Safran, 2014), *willingness to ask for help* (Fischer, David, Crotty, Dierks, & Safran, 2014), *trust in the technology* (Fischer, David, Crotty, Dierks, & Safran, 2014), *technology design challenges* (Fischer, David, Crotty, Dierks, & Safran, 2014), *access* (Finkelstein, et al., 2012), *lack of training* (Finkelstein, et al., 2012), and *low computer literacy* (Rios, 2013; Finkelstein, et al., 2012).

Systems that are considered intrusive or causing infringement on privacy might still be accepted by older adults if their health needs are great enough, according to (Pietrzak, Cotea, & Pullman, 2014).

Important motivating factors for the use of technology include *increased independence* (Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd, 2014), *safety* (Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd, 2014), *control* (Hawley-Hague, Boulton, Hall, Pfeiffer, & Todd, 2014), *satisfaction*

(Finkelstein, et al., 2012), *usefulness* (Finkelstein, et al., 2012), *efficiency* (Finkelstein, et al., 2012), and *convenience* (Jimison, et al., 2008).

The importance of technical support and supervision is emphasized by (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014; Pietrzak, Cotea, & Pullman, 2014). At least one review suggests that the user interface needs to be tailored to and tested by the elderly users (Pietrzak, Cotea, & Pullman, 2014). Informational websites need to be better attuned to users with dementia, and should offer personalized information (Lauriks, et al., 2007).

Many older adults consider monitoring technology suitable for "others" or "someone else who may need it", indicating that they have a different perception of their own health needs compared to the perception of their caregivers and family members (Wagner, Basran, & Dal Bello-Haas, 2012).

Low computer literacy is common among older adults and a major barrier to technology acceptance. Having access to health information and skills to effectively find and use information to solve health problems is important in increasing eHealth literacy (Rios, 2013).

In the case of fall detection, the elderly want devices that can accurately detect falls, while at the same time be as unobtrusive as possible (Chaudhuri, Thompson, & Demiris, 2014).

When evaluating the acceptance of technology in an aging-in-place context, it is often not sufficient to use a single evaluation method. A wide range of evaluation techniques should be considered in order to provide the richest insights for a particular project: "*In addition to the normal measures for health outcomes, there is a need to be able to measure the users' experiences with technology: when, how and why will older adults and their caregivers use technology? Such questions require a multimodal approach to evaluation to gain deeper insights into how we may design technologies that are acceptable to people"* (Connelly, Mokhtari, & Falk, 2014).

4.2. Findings from primary sources

In multiple studies, the elderly have expressed that they generally have a positive attitude towards ICT (Lu, Chi, & Chen, 2014; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Chung, et al., 2014; Demiris, Oliver, Dickey, Skubic, & Rantz, 2008; Alwan, et al., 2006; Chen, Harniss, Patel, & Johnson, 2014; Demiris, et al., 2004; Demiris, Hensel, Skubic, & Rantz, 2008). However, there are many factors affecting acceptance, both in positive and negative ways. This section will take an in-depth look into the different categories that affect acceptance of health ICT the most, summarizing the findings from the primary sources. We first review factors that seem to increase acceptance, and then present barriers to acceptance. In each section, we have tried to order the topics so that topics with most evidence appear first.

4.2.1. Factors increasing acceptance

4.2.1.1. Support for independence

In many of the studies, participants emphasised the importance of being able to live independently in their own homes for as long as possible (Jaschinski & Allouch, 2015; Loh, Flicker, & Horner, 2009; Gövercin, et al., 2010; Sanders, et al., 2012; Damodaran, Olphert, & Phipps, 2013; Demiris, et al., 2012). In one study, the participants reported a feeling of accomplishment when they managed to carry out an activity on their own, and they all aspired to use the Internet without relying on others (Sayago & Blat, 2011). In another study, the elderly envisioned a telehealth kiosk as a tool that can enhance their independence and control over their health status (Demiris, et al., 2012).

However, some issues regarding technologically aided independence were also reported. In one study, the authors write: "*Most respondents indicated that they associated the use of telehealth and telecare with a high degree of dependency and ill health. In the majority of cases, respondents seemed to want*

to distance themselves from negative connotations of old age, sickness and dependence, and instead depicted themselves as having a strong sense of personal responsibility for maintaining health, self-care and independence that could be threatened by the interventions. (...) Responses commonly indicated a strong sense of personal responsibility for health, illness and self care; and the interventions threatened to undermine such a sense of 'control' and current approaches to managing health problems" (Sanders, et al., 2012). Similarly, participants in another study reported that they did not use assistive technologies because they viewed them as something that belonged in a hospital, and felt that it brought them one step closer to institutional care or death (Greenhalgh, et al., 2013).

4.2.1.2. Increased safety and security

Studies reported a feeling of safety and security as a result of using ICT, and/or a desire to use ICT to prevent or detect accidents and medical emergencies (Lu, Chi, & Chen, 2014; Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Gövercin, et al., 2010; Steele, Lo, Secombe, & Wong, 2009; Sjölinder & Avatare Nöu, 2014; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2004; Alexander, et al., 2011; Demiris, Hensel, Skubic, & Rantz, 2008).

In two of the studies, the participants emphasized the importance of facilitating communication between the patient and healthcare providers or emergency services when they needed help (Sjölinder & Avatare Nöu, 2014; Parker, Jessel, Richardson, & Reid, 2013). According to Sjölinder and Avatare Nöu: "*The lack of feedback reduced the feeling of safety and increased the uncertainty regarding whether someone would help.*" (Sjölinder & Avatare Nöu, 2014). There was also a wish for social alarms to work outside the home, which would let the elderly go out without feeling unsafe (Sjölinder & Avatare Nöu, 2014; Demiris, et al., 2004). Another study found that the elderly wanted devices or sensors that can detect a range of different emergencies (Demiris, et al., 2004).

However, safety and security seem to exist in a context that includes more than just being monitored by the healthcare provider. Sharing health-related information with family members and healthcare providers was a requested feature (Kutz, Shankar, & Connelly, 2013; Price, Pak, Müller, & Stronge, 2013). In cases where assistive technologies have a limited uptake and use, one explanation could be that the solution focuses purely on providing safety to the user, but does not improve the lived experience of impairment: "*Many of the assistive technologies in this study (e.g. blood pressure monitoring, falls detectors, alarms) had been supplied after an acute event (e.g. stroke, fall). They served, at best, to provide objective information (biometric data, emergency alerts) to health and/or social care providers. But they did not improve the lived experience of impairment. Indeed, they were not designed to do so - but therein may lie one explanation for their limited uptake and use.*" (Greenhalgh, et al., 2013).

4.2.1.3. Support for socialisation

Elderly users wish to use ICT to socialize and play a more active role in society (Sayago & Blat, 2011; Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Demiris, et al., 2012). This is stated by Sayago and Blat: "*A key and common motivation for all the participants to use the web was to socialize. They did not want to do activities that could isolate them.*" (Sayago & Blat, 2011). Elderly users value the ability to communicate with family and friends through ICT (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Damodaran, Olphert, & Phipps, 2013) and are positive toward using ICTs to prevent social isolation (Sayago & Blat, 2011; Jaschinski & Allouch, 2015). Most want to learn more about ICT in order to maintain an active engagement in life and society (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015). By getting the elderly out of the house and be more socially active, they can get back a sense of life, as well as stimulate their activity level (Jaschinski & Allouch, 2015).

In one study (Steele, Lo, Secombe, & Wong, 2009), participants did not perceive any ICT system to impose any changes on their social lives, and stated that their social trends would not be affected by

such a system. They strongly opposed to the idea of notifying family members about lack of social activities, and similar functionalities.

4.2.1.4. Availability of proper training

Generally, the elderly find it important to get sufficient training and coaching in the usage of the ICT system (Sayago & Blat, 2011; Steele, Lo, Secombe, & Wong, 2009; Chung, et al., 2014; Damodaran, Olphert, & Phipps, 2013; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2004). Tailored training was considered as the best way to bridge the gap of the digital divide (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015). However, the quality of these training sessions can vary. In one of the studies, the majority of the participants stated that they still did not know how to use the system after the training session (Lu, Chi, & Chen, 2014). In this specific case, the reported reasons were too little training, and lack of access to any kind of help on how to use the device afterwards.

Some users' perception is that the system is more complicated to operate than it actually is (Sanders, et al., 2012). This might cause users to give up on even trying to participate in training sessions. Some users state that they have no interest in learning how to use computers (Goodall, Ward, & Newman, 2010).

The number of ICT training courses exclusively available for older adults is limited, and information about ICT training opportunities is generally poorly publicised (Damodaran, Olphert, & Phipps, 2013). Some people get training from their family and friends (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015). However, one study found that the children of the elderly are generally not the most appropriate teachers, as they tend to be impatient and speak computer jargon without explaining the meaning of technical terms (Sayago & Blat, 2011).

When learning how to use an ICT system, an expert should sit down with the user and guide him/her systematically through the operating process (Lu, Chi, & Chen, 2014). Repetition is also crucial, since many elderly are prone to cognitive conditions and thus have a harder time remembering how to perform certain tasks (Lu, Chi, & Chen, 2014) (See also section *4.2.2.3*). A trainer should be patient, have perseverance, and use understandable language (Sayago & Blat, 2011). The training itself should be accessible, timely, affordable, tailored, local, and in a welcoming and safe environment (Damodaran, Olphert, & Phipps, 2013). The elderly also want an instruction manual that they can consult when they are unsure how to perform a certain task (Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2004). This manual should be designed specifically for senior citizens, written in a non-jargon language (Demiris, et al., 2004).

4.2.1.5. Managing own health

Elderly users are positive towards using ICT to help manage their own health, by getting information about their current health status (Lu, Chi, & Chen, 2014; Trief, et al., 2008; Chung, et al., 2014; Demiris, et al., 2012; Price, Pak, Müller, & Stronge, 2013). The perceived benefit is that this will make them less dependent on their physician, and make them more aware of their own health problems and underlying causes. One study (Price, Pak, Müller, & Stronge, 2013) lists the following desired functionality for a "magic box" tool for managing their health information:

> *"Participants expressed a need for a tool that will store all their health information in one place and allow them to share this information with healthcare providers and family members. The e-health tool should be interactive, and help users manage appointments, medications, bills, and statements. It should provide reminders for various health tasks, and provide a diagnosis or answer questions about a concern based on the personal health information stored within the tool. They want a tool that would track their health status over time, and give general health advice based on their personal health information. Older adults indicated that they would prefer to have the responsibility of entering information into the "magic box", rather*

than giving this responsibility to their doctor. It should provide easy accessibility to their records for healthcare providers".

4.2.1.6. Access to online information

In two of the studies, participants valued the ability to use the Internet for information searching (Damodaran, Olphert, & Phipps, 2013; Campbell, 2008). In (Campbell, 2008), the participants stated that they felt the Internet was "*good for finding information that the physicians don't tell you about or forget.*" However, in another study, some participants considered it a social injustice that people have no choice but to use new technologies to get access to information and services (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015).

4.2.1.7. Support for daily activities

In three of the studies, participants stated that they used ICTs to aid them in their daily activities, and appreciated this ability. Activities supported by technology include chores and reminders (e.g. medicine and important appointments) (Jaschinski & Allouch, 2015), online banking, shopping online, writing letters and financial budgeting (Damodaran, Olphert, & Phipps, 2013), and enhancing their lives and increasing their productivity in general (Campbell, 2008).

4.2.1.8. Perceived usefulness

The elderly population generally find the functionality offered by health ICT systems useful (Jung & Loria, 2010; Lu, Chi, & Chen, 2014; Trief, et al., 2008; Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2012; Alexander, et al., 2011; Demiris, Hensel, Skubic, & Rantz, 2008). This might be linked with their desire for increased independence and/or quality of life: "*Determination in sustaining one's independence can affect a WSN [Wireless Sensor Network] system's PU [perceived usefulness] and any indication on WSN's ability to improve an elderly individual's quality of life would appear to have a positive impact on the system's PU.*" (Steele, Lo, Secombe, & Wong, 2009). However, one study found that the elderly "*did not uniformly accept the smart home IT shown and most indicated a preference for being able to select only the technologies they perceived they needed*" (Courtney, 2008).

4.2.1.9. Support / help

Several studies found a distinct correlation between the support available to the user, and the users' acceptance and attitudes towards the ICT system (Steele, Lo, Secombe, & Wong, 2009; Damodaran, Olphert, & Phipps, 2013; Greenhalgh, et al., 2013). In one of the studies, the authors write: "*The availability of help and support has emerged as a key factor of paramount importance to sustaining connection. (...) Human support and encouragement was reported by a significant number (25.2 per cent) of survey respondents to be the most important thing to help them use technology successfully. Most of this help and support was gained informally from family and friends.*" (Damodaran, Olphert, & Phipps, 2013). Another study states: "*Most participants pointed out that the availability and quality of user support is crucial in determining whether users can interact successfully with the technology.*" (Steele, Lo, Secombe, & Wong, 2009).

4.2.2. Factors preventing acceptance

4.2.2.1. Violation of privacy

Many studies found that some or all participants have concerns about privacy (Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Gövercin, et al., 2010; Steele, Lo, Secombe, & Wong, 2009; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2004; Price, Pak, Müller, &

Stronge, 2013; Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Courtney, 2008; Demiris, Hensel, Skubic, & Rantz, 2008) (Greenhalgh, et al., 2013; Young, Willis, Cameron, & Geana, 2014). Privacy is regarded as a "*bigger barrier to adoption, more so than usability*" (Price, Pak, Müller, & Stronge, 2013). One of the most cited reasons is that the technology makes the elderly feel observed (Jaschinski & Allouch, 2015; Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2004; Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008), e.g. by the use of optical sensors and video surveillance (Demiris, et al., 2004; Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008; Gövercin, et al., 2010). In particular, the use of cameras is seen as a challenge to privacy: "*All participants felt that the use of cameras within their homes for the purpose of identifying falls or other accidents was 'obtrusive' and would be violating the resident's privacy.*" (Demiris, et al., 2004).

Elderly users want to be able to control the frequency and location of monitoring (Demiris, Oliver, Giger, Skubic, & Rantz, 2009). Some would like to be able to turn the system off (Jaschinski & Allouch, 2015; Demiris, Oliver, Giger, Skubic, & Rantz, 2009), and some would even like the option to "get rid of it" when desired (Steele, Lo, Secombe, & Wong, 2009). However, some think such a surveillance system would only work to its full potential when it cannot be switched off (Jaschinski & Allouch, 2015). One study reported cameras that only detected shadows or silhouettes and movements, and thus hid identifiable features. Users perceive this as less obtrusive compared to a conventional video surveillance system (Demiris, et al., 2004; Demiris, Oliver, Giger, Skubic, & Rantz, 2009).

Elderly users want to control what data to share and with whom (Jaschinski & Allouch, 2015). Most would grant access rights to their healthcare providers and others who need to process the information for the purposes of monitoring (Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008). Some expressed that they wanted to grant access to their family members (Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008), while others expressed privacy issues with family members having access rights (Demiris, Oliver, Giger, Skubic, & Rantz, 2009). Some users want to have the ability to access their own data collected from sensors (Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008). In one study, the participants thought their physicians ought to be able to see how much activity they were engaged in, while they did not think their caregivers, spouses or children would be interested in that level of detail (Chen, Harniss, Patel, & Johnson, 2014).

The elderly population lacks knowledge about computer security (Damodaran, Olphert, & Phipps, 2013). They are worried that their information is not stored securely (Price, Pak, Müller, & Stronge, 2013; Young, Willis, Cameron, & Geana, 2014), and fear that it can be hacked (Young, Willis, Cameron, & Geana, 2014). Some accepted that they had to trade privacy and security for perceived utility (Young, Willis, Cameron, & Geana, 2014).

Despite there being many reported barriers relating to privacy, several studies found that the participants did not have any issues with privacy (Jung & Loria, 2010; Chung, et al., 2014; Demiris, Oliver, Dickey, Skubic, & Rantz, 2008; Chen, Harniss, Patel, & Johnson, 2014; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2012). They expressed that they had no concerns about the use of cameras (Demiris, Oliver, Giger, Skubic, & Rantz, 2009), GPS tracking (Sjölinder & Avatare Nöu, 2014), nor wireless transmission of health data (Steele, Lo, Secombe, & Wong, 2009). Reasons for this include that they trust the service provider (Jung & Loria, 2010), that the monitoring provides peace of mind (Demiris, Oliver, Dickey, Skubic, & Rantz, 2008), and that they value security over privacy (Steele, Lo, Secombe, & Wong, 2009; Courtney, 2008). Therefore, there needs to be a balance between the benefits of monitoring and the perceived invasion of privacy (Demiris, Oliver, Dickey, Skubic, & Rantz, 2008; Demiris, Hensel, Skubic, & Rantz, 2008).

4.2.2.2. Interaction design

Some elderly users have both physical and cognitive impairments, and are not good at learning to use new technology. It is important that the system is user friendly and requires minimal to no user action

(Demiris, et al., 2004). Several factors relating to ease of use and HCI were found to have a negative impact on acceptance when such impairments are present (see also the following two sections). For instance, visual communication in a graphical user interface can be challenging. Icons are confusing, and some users prefer text (Sayago & Blat, 2011). Buttons can be too small (Chen, Harniss, Patel, & Johnson, 2014; Goodall, Ward, & Newman, 2010). Users have low confidence and are afraid of doing something wrong, and do things slowly to minimize chance (Sayago & Blat, 2011). Cognitive overload can be a larger problem for elderly users than younger users, e.g. too many system functions can lead to confusion (Goodall, Ward, & Newman, 2010). There is also a tendency to automate some tasks so users won't need to be involved in the interaction: "*An elderly person's preference on the system design, personal preferences and several external factors it appears can affect a user's PEOU [perceived ease of use] of the system. An embedded solution with an easy to understand and good usability is the most accepted implementation among the participants, suggesting that interaction with the system may be 'an automatic thing' or 'as simple as 'push the button''.*" (Steele, Lo, Secombe, & Wong, 2009).

4.2.2.3. Memory and cognitive abilities

Several studies found that elderly people often forget how to use the technology, or forget to use it at all, due to age-related cognitive impairment. This includes keeping track of devices (Parker, Jessel, Richardson, & Reid, 2013), putting on wearable sensors (Steele, Lo, Secombe, & Wong, 2009), charge battery-driven devices (Chen, Harniss, Patel, & Johnson, 2014), and remembering passwords and steps in a process (Damodaran, Olphert, & Phipps, 2013).

ICT can be used to compensate for these cognitive difficulties (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Demiris, et al., 2012). However, this kind of functionality can also have negative effects: "*For some, reminders about appointments or to take medicine were seen as unnecessary or even insulting, an indication that one could not manage health affairs without assistance*." (Young, Willis, Cameron, & Geana, 2014).

4.2.2.4. Physical abilities and ergonomics

A recurring theme in several studies was that interfaces, including computer mice and small buttons, were not tailored to the elderly population with functional limitations (Sayago & Blat, 2011; Damodaran, Olphert, & Phipps, 2013; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2012; Demiris, et al., 2004; Alexander, et al., 2011; Goodall, Ward, & Newman, 2010). Demiris et al. state that "*The majority of interfaces [of new technological devices] are not designed to take into consideration the functional limitations that come with age. As a result, some tasks requiring the use of technological devices become even more difficult for the older adult.*" (Demiris, et al., 2004)

One study found that the elderly preferred using the keyboard instead of the mouse, due to normal age-related changes in precision and manual dexterity (Sayago & Blat, 2011). They did not want to use alternative input devices in order to avoid stigmatisation, and they had issues with using accessibility tools for making text and elements larger, since this increased cognitive demands by moving or removing elements.

4.2.2.5. Comprehension and awareness

Several of the studies found that participants had problems with understanding the technology and/or the terminology (Steele, Lo, Secombe, & Wong, 2009; Damodaran, Olphert, & Phipps, 2013; Alexander, et al., 2011; Goodall, Ward, & Newman, 2010; Greenhalgh, et al., 2013). They often have trouble understanding how to use the technology, and/or its purpose, as demonstrated by the following quotations from the studied articles:

- "*Responses suggested that participants did not understand the technology.*" (Goodall, Ward, & Newman, 2010)

- "*Many had a hazy understanding of their assistive technologies, and we found one fully installed and functioning alarm system (with pendant) of which the intended user claimed to be unaware.*" (Greenhalgh, et al., 2013)

- "*Many participants reported that they had difficulties understanding technical 'jargon'.*" (Damodaran, Olphert, & Phipps, 2013)

- "*It is evident that the functionalities and benefits of WSN [Wireless Sensor Network] systems is a concept some elderly persons find hard to grasp. (...) They [participants] expressed their frustration in not being able to understand what happened when error occurs and hence expressed a desire for the system to have 'common sense' and give out meaningful and easy to understand error messages.*" (Steele, Lo, Secombe, & Wong, 2009)

4.2.2.6. Obtrusiveness / intrusiveness

It is important to the elderly users that system components are unobtrusive (Gövercin, et al., 2010; Steele, Lo, Secombe, & Wong, 2009; Chung, et al., 2014; Demiris, et al., 2004; Demiris, Hensel, Skubic, & Rantz, 2008). Generally, smaller devices are perceived as less intrusive, and technological devices installed in the home should be hidden or hard to see for visitors (Demiris, Hensel, Skubic, & Rantz, 2008). The use of cameras for video surveillance is considered "too intrusive" (Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2004). In the case of wearable devices, the elderly prefer to wear them on their wrist, and female users want sensors that can be worn as jewellery (Gövercin, et al., 2010).

In several studies, the participants answered that they were not bothered by the technology, and/or that it did not interfere with their daily activities, which would indicate that the developers succeeded in creating an unobtrusive system (Chung, et al., 2014; Demiris, Oliver, Dickey, Skubic, & Rantz, 2008; Chen, Harniss, Patel, & Johnson, 2014; Demiris, Hensel, Skubic, & Rantz, 2008). In one study, participants pointed out that some people are 'technophobes', and refuse to utilize new technologies (Demiris, et al., 2004). See also section *4.2.3 Other findings*.

4.2.2.7. Fear, anxiety, and discomfort with use

Many elderly people might experience discomfort, anxiety or even fear while using ICT (Sayago & Blat, 2011; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Steele, Lo, Secombe, & Wong, 2009; Alwan, et al., 2006; Damodaran, Olphert, & Phipps, 2013; Greenhalgh, et al., 2013; Young, Willis, Cameron, & Geana, 2014). In one study, participants stated that they are “terrified of a computer” (Steele, Lo, Secombe, & Wong, 2009). Possible causes for these feelings include a low level of comfort with and control of technology, age-related cognitive difficulties, or a lack of familiarity (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Steele, Lo, Secombe, & Wong, 2009; Young, Willis, Cameron, & Geana, 2014). Elders are afraid of not getting help quickly if they were to fall while using a fall detection service (Alwan, et al., 2006). At the same time, they might be uncomfortable using such a service because of many different reasons:

> *“Others viewed the pendant alarm as potentially exposing them to sinister intrusion or surveillance by unwanted strangers, or as threatening to precipitate dramatic scenarios that were embarrassing (e.g. ambulance arriving when they were not dressed), socially disruptive (e.g. disturbing their children at work) or personally threatening (e.g. leading to unwanted hospital admission). When such perceptions were held, the device was rarely, if ever, activated.” (Greenhalgh, et al., 2013).*

One study found that connectivity could increase older adults’ comfort with technology in general (Parker, Jessel, Richardson, & Reid, 2013).

4.2.2.8. Low technological self-efficacy

Elderly users often doubt their own abilities to understand and properly use ICT solutions (Jung & Loria, 2010; Steele, Lo, Secombe, & Wong, 2009; Sanders, et al., 2012). One possible reason for this could be that many have had negative experiences with technology in the past, where they were unable to interact with the technology properly (Steele, Lo, Secombe, & Wong, 2009). However, one study found that even those with the least Internet experience and lowest self-efficacy in the study, reported being confident in their ability to use the services once they had tried them (Jung & Loria, 2010).

4.2.2.9. Digital divide and generational differences

Elderly people are concerned about using technologies that can make them look different and frail, and they want to be able to use the same technology as their children and grandchildren are using, both to feel closer to them, and to dispel stereotypes they could have about them (Sayago & Blat, 2011). However, most elderly people are unable to follow the technological trends, which might make some feel labelled as old fashioned and obsolete, which in turn can make them feel inferior or powerless:

> *"They [participants] frequently reported social pressure that pushes them to use technologies in order to fit in with the society. Otherwise, they would be excluded from it"* (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015).

One study found an exception to the theory that the digital divide is a significant barrier to the adoption of e-health tools:

> *"Older adults in this study were more likely to adopt some form of technology than younger adults (e.g., create a medication list within a word document). Older adults' willingness to adopt some form of technology may reflect the perceived usefulness and importance of the task of remembering medications, as well as the usefulness of being able to easily edit and print the same information to a multitude of healthcare providers"* (Price, Pak, Müller, & Stronge, 2013).

4.2.2.10. Stigmatization and pride

The installation of heathcare ICT solutions may cause some elders to feel stigmatized or ashamed (Jaschinski & Allouch, 2015; Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2004; Demiris, Hensel, Skubic, & Rantz, 2008). For instance, Jaschinski and Allouch write:

> *"While assistance with chores was well perceived by a few older adults, others felt no need for assistance and almost felt insulted by the idea (...). We observed that some older adults were very proud of their independence and therefore, rejected anything which would imply otherwise"* (Jaschinski & Allouch, 2015).

Users might not want to be seen wearing a health monitoring device, as they were afraid it would stigmatize them as frail or needing special assistance. (Steele, Lo, Secombe, & Wong, 2009; Demiris, et al., 2004).

4.2.2.11. Financial cost

Generally, elderly people see the cost of a health-related ICT solution as an important concern when deciding if they want to buy it (Lu, Chi, & Chen, 2014; Jaschinski & Allouch, 2015; Steele, Lo, Secombe, & Wong, 2009; Damodaran, Olphert, & Phipps, 2013; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2004; Goodall, Ward, & Newman, 2010; Young, Willis, Cameron, & Geana, 2014). As stated by Steele et al.: "*Cost was the most significant concern to the elderly participants.*" (Steele, Lo, Secombe, & Wong, 2009). ICT systems need to be affordable for elderly people living on a pension if it is to get a large user base. However, in one of the studies, cost savings for the user was

mentioned as a benefit, as it is cheaper (or even free) to use the ICT solution once it is installed, rather than get an appointment with a doctor (Jung & Loria, 2010).

4.2.2.12. Lack of human interaction

An ICT system should not replace human contact. The elderly emphasised the importance of having human care and human interaction, and the thought of replacing this with a computer caused concern (Jaschinski & Allouch, 2015; Loh, Flicker, & Horner, 2009; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015).

> *"The need for human contact and a warm relationship appeared paramount to the residents. This was simply and forcefully expressed by a resident who said simply: 'We are not robots here.' More importantly the residents were 'one voice' and in consensus about human contact." (Loh, Flicker, & Horner, 2009)*

4.2.2.13. Reliability and trust

Elderly users often have some degree of mistrust or concern about the reliability of an ICT system (Lu, Chi, & Chen, 2014; Jaschinski & Allouch, 2015; Steele, Lo, Secombe, & Wong, 2009; Parker, Jessel, Richardson, & Reid, 2013; Demiris, et al., 2004; Demiris, Hensel, Skubic, & Rantz, 2008; Young, Willis, Cameron, & Geana, 2014). These concerns involve the accuracy of devices (including false alarms) (Lu, Chi, & Chen, 2014; Jaschinski & Allouch, 2015; Steele, Lo, Secombe, & Wong, 2009; Demiris, Hensel, Skubic, & Rantz, 2008), uncertainty about whether a device is malfunctioning or not (Lu, Chi, & Chen, 2014; Steele, Lo, Secombe, & Wong, 2009), depleted batteries (Steele, Lo, Secombe, & Wong, 2009), delivering information to providers in a timely manner (Parker, Jessel, Richardson, & Reid, 2013), and trusting that the computer would do its job (Young, Willis, Cameron, & Geana, 2014).

4.2.2.14. Readiness to adopt technology

Many elderly are reluctant or not at all interested in using the ICT solution after getting a presentation, demonstration or having tried it themselves (Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Steele, Lo, Secombe, & Wong, 2009; Demiris, Hensel, Skubic, & Rantz, 2008; Goodall, Ward, & Newman, 2010; Young, Willis, Cameron, & Geana, 2014). They find they have no need for it in their current situation (Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Young, Willis, Cameron, & Geana, 2014), and think of it as something more appropriate for people who are older, frailer, less independent, less active, less healthy and/or more isolated than themselves (Jaschinski & Allouch, 2015; Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015; Sanders, et al., 2012; Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Demiris, Hensel, Skubic, & Rantz, 2008; Young, Willis, Cameron, & Geana, 2014). Some acknowledge that they soon will be in need of such technology (Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015), while others find this hard to imagine (Jaschinski & Allouch, 2015). Some perceive computers as something only young people use (Goodall, Ward, & Newman, 2010).

4.2.2.15. Other barriers

Some elderly people are worried that a wearable sensor system can have negative effects on their health, like getting cancer from radio waves used for wireless communication, getting allergic reactions, or the pain caused by having an implanted sensor (Steele, Lo, Secombe, & Wong, 2009). One study investigating self-tracking of data (Ancker, et al., 2015) found that elders who tracked their health data themselves recognized this as work, and judged themselves as "good" or "bad" for their data and their diligence in collecting it, and noted that data should be considered within the patient's personal context. Medical data often reminded patients of the negative aspects of their illness, which made many give up self-tracking.

4.2.3. Other findings

The elderly report positive attitudes towards wearable sensors (Gövercin, et al., 2010; Steele, Lo, Secombe, & Wong, 2009). They do not mind the concept of wearing sensors on their body (Steele, Lo, Secombe, & Wong, 2009), and prefer wearable sensors over an optical system (ambient monitoring) (Gövercin, et al., 2010). A wristband sensor is well accepted (Gövercin, et al., 2010), and having sensors embedded into clothing accessories such as rings or watches was also requested (Steele, Lo, Secombe, & Wong, 2009). Women want to be able to wear sensors as jewellery (Gövercin, et al., 2010). Some problems identified with wearable sensors include that users might refuse to wear them at all times, and might end up not wearing it in an emergency, and they have limited mobility as the sensor functions only within a certain area (Demiris, et al., 2004).

In the case of ambient monitoring, the elderly are uncertain whether a pure ambient implementation is adequate to ensure that an elderly person is monitored at all times. Some suggest a hybrid solution consisting of both ambient and embedded sensors may be better for solving perceived problems (Steele, Lo, Secombe, & Wong, 2009). The elderly are reported in one study to be positive towards the idea of having embedded sensors placed under their skin, as long as the pain is not significant, and the chip did not need to be taken out regularly e.g. for battery replacement (Steele, Lo, Secombe, & Wong, 2009).

4.3. Mapping to UTAUT2

In this section we aim to structure our findings from the literature by mapping them to the constructs in the UTAUT2 model (Venkatesh, Thong, & Xu, 2012). We first summarize what our data say about each construct in the original model. We then propose adding two new constructs to the model based on data that we cannot map to the existing constructs.

4.3.1. Performance expectancy

Performance expectancy is defined in UTAUT2 as "*the degree to which using a technology will provide benefits to consumers in performing certain activities*" (Venkatesh, Thong, & Xu, 2012). Our findings show that elderly users living in the community expect specific benefits from technologies; these benefits might be different from those expected by other user groups. Elderly users expect health-related technologies to support them in staying independent, and staying an active member of the society. Becoming dependent on others is a fear that most seniors have. It might be that general attitudes in the society towards getting old amplifies this fear. For instance, elderly are often seen as a cost to the society. Technologies that can alleviate this fear seem to be valued and accepted by our user group. This can be technologies for performing daily activities and chores, technologies for managing own health as much as possible, technologies for staying safe without posing a burden on others, and technologies for keeping socially involved and included—with family and in society. Our specific user group might have an amplified attitude towards these benefits because they need the benefits in order to live independently. Performance expectancy is moreover an important aspect in the community setting because users are often in charge of their own behaviour –i.e. cannot be guided by a doctor – and have their own routines and habits that can be hard to change. If seniors living in the community cannot see a benefit in using the technology, they will simply not use it.

4.3.2. Effort expectancy

Effort expectancy is defined as "*the degree of ease associated with consumers' use of technology*" (ibid.). Many of our findings show that elderly users put emphasis on perceived and real ease-of-use. A major factor contributing to increased effort to use technology is impairment, both physical and cognitive. Technologies that are developed for physically and mentally healthy adults can be perceived as too difficult or impossible to use for many elderly users. The studied literature mentions a number

of specific usability issues, such as icons and symbols, font size, and number of functions. At the same time, we need to avoid stigmatization by creating dumb technology that we label "senior-friendly".

Our data also shows that elderly users appreciate unobtrusive technology, i.e. technology that can operate in the background without the need for much user intervention. This might be technology that a doctor needs for health monitoring, or technology that is used for monitoring safety of e.g. people with dementia. In general, seniors might consider themselves as having low technological self-efficacy. It is therefore important to consider the amount of prior technical knowledge required to use a technology, even if the technology itself is easy to use. For instance, a wearable technology that requires the use of a new type of smartphone might require too much effort for some age groups.

4.3.3. Social influence

Social influence is "*the extent to which consumers perceive that important others (e.g., family and friends) believe they should use a particular technology*" (ibid.). In a peer network, stigmatisation and jeopardising personal pride are two strong social influencers. Several studies show that if a technology is developed to look like or function in a stigmatising way, it will have low acceptance. Seniors tend to want to use technology that younger generations use. At the same time, there are generational differences in some well-accepted technologies, which might mean that peer acceptance or perceived value can remove or soften some of the stigmatising effects.

At a non-peer network, it seems that family members and healthcare personnel have some level of influence on seniors.

4.3.4. Facilitating conditions

Facilitating conditions refer to "*consumers' perceptions of the resources and support available to perform a behavior*" (ibid.). There are two central sets of findings. First, elderly users might need substantial training and support in using health-related technologies. Second, using some forms of health-related technology is associated with trust and safety, which might imply the need for continuous support by a service provider –e.g. in case of a personal emergency alarm.

Many health-related technologies are introduced into the lives of seniors at a relatively late point in time, often when impairment has already made it difficult for them to learn new skills. This means that training and help when using the technology become essential facilitating factors. Our findings show that learning to use new technology needs highly tailored training. At the same time, it is important to provide follow-up training also after the initial training is over and the technology is in use.

Elderly users show a general lack of trust in technology, and are often uncertain whether it works or not. This might be partly because the technology is not designed well—e.g. it does not provide proper feedback to the user. However, we also believe it shows a need to be assured that a service provider is "watching over" them. In particular, safety-related technologies such as fall detection create an expectation that a service provider is continuously monitoring and will react in emergencies.

4.3.5. Price value

Price value is defined in UTAUT2 as "*consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them*" (ibid.). Healthcare systems in different countries have different reimbursement practices. It is therefore difficult to say much about how the price of a health-related technology is valued by seniors. In Norway, for instance, most health-related services and technology are paid by the state-owned health insurance, while in other countries such as USA this is vastly different. We have not mapped our studies onto country-specific reimbursement systems. However, most of the studied that mention cost at all consider it as a major issue for the seniors.

4.3.6. Hedonic motivation and Habit

The two other constructs in UTAUT2 are hedonic motivation ("*the fun or pleasure derived from using a technology*") and habit ("*the extent to which people tend to perform behaviors automatically because of learning*") (ibid.). Our findings do not show any direct evidence of their importance to elderly users.

One hypothesis that can explain the lack of hedonic aspects is the disease-centeredness of health-related technologies. Most health-related technology is designed "to solve a problem" and therefore might lack any "fun factor". The emergence of gamification and game-based health-related technologies might make hedonic motivation a stronger aspect of acceptance in the near future.

We were, however, surprised that habit does not show up as a relevant factor in our included studies. It might be that many of the barriers that are identified—e.g. fear of technology, low self-efficacy—are actually symptoms of a habit of not using technology. It might also be that the studied users have rarely used assistive technologies long enough in order to allow for habit creation.

4.3.7. Moderating conditions

Regarding the moderating conditions in UTAUT2, i.e. age, gender and experience, we find support for age, partly for experience, but not for gender. Obviously, age is a strong moderator in our studies because we focused on age as an inclusion criteria for our literature survey. So all the findings aim to illustrate how age affects acceptance. It is however surprising for us that gender does not show up as a topic in the included studies. Initial studies on UTAUT and UTAUT2 mention gender as a major moderator.

Experience is neither a topic in the included studies. The majority of studies in this review focused on users with very little to no prior experience with a certain type of ICT, or with ICT in general. Thus, we cannot draw any conclusions regarding the experience moderator. So far, seniors have not belonged to the "Internet generation", and have not used advanced ICT as adults. It might also be that researchers assume a lack of experience and therefore do not collect data about prior experience. Another theory can be that many health-related technologies demonstrate a departure from "normal" ICT platforms that seniors are potentially familiar with. Many assistive technologies rather resemble medical devices than domestic ICT. In other words, it becomes irrelevant to talk about prior experience because you enter a new ICT world when you become senior.

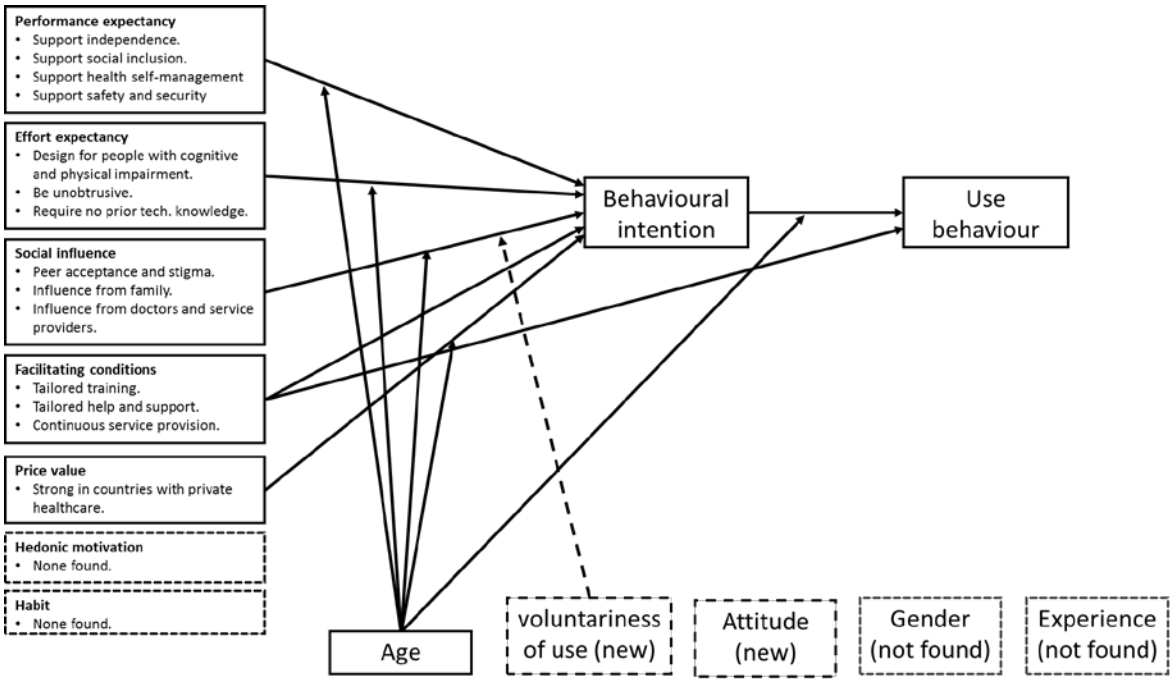

Figure 2: Mapping of the findings to UTAUT2.

4.4. Findings that are not mapped to UTAUT2

Our findings show that privacy and information security emerge as a major topic. We see both positive and negative attitudes towards sharing of private and health-related data. The same applies to perceived usefulness of health-related technologies. Some elderly users find it very useful while some are very sceptical. It is difficult for us to see how UTAUT2 can express these variations. We believe introducing a construct called "attitude" might help. Attitude was included as a parameter in a number of acceptance models that were reviewed in the original UTAUT article (Venkatesh, Morris, Davis, & Davis, 2003), but its authors eliminated this parameter in the favour of performance expectancy.

Another observation we have is related to the moderating condition "voluntariness of use" that was part of the original UTAUT model. This parameter is removed from UTAUT2 because its authors believe it is irrelevant for consumer ICT. We always buy and use consumer ICT voluntarily. This might be correct. However, we believe health-related technologies for home are not completely consumer ICT. They are neither completely "institutional" ICT as in the original UTAUT. For instance, elderly users might be motivated to use health-related technology if an authoritative person such as a doctor recommends the technology. In the same way, in many countries with public welfare services, assistive technologies might be the only option available among the publicly funded services—e.g. in case of personal emergency response systems for monitoring of falls and accidents. Users might feel forced to accept them as they are. In these cases it is important to be able to measure how a low or high level of voluntariness can affect the acceptance and use of assistive technologies at home.

5. Discussion

Figure 3 shows the result of the mapping of data from our study onto the UTAUT2 model. For some of the constructs we have provided some details about what each construct means for the elderly user group. Some constructs and moderating conditions are not supported by our data (hedonic motivation, habit, gender and experience). We also propose to add two new constructs, i.e. attitude and voluntariness of use, which need to be verified by future research. This mapping provides, we hope, a

useful model for those who design health-related technologies for the elderly user group. All our proposals are based on the reviewed literature. They however need to be verified in future studies so that their exact impact and statistical significance can be clarified.

Our data shows a context for technology acceptance that falls somewhere between the original UTAUT and UTAUT2. The original UTAUT was developed in order to explain technology acceptance in organizational settings (Venkatesh, Morris, Davis, & Davis, 2003). UTAUT2 was developed for the consumer market because the original model was not expressive enough. It added the constructs price value, hedonic motivation, and habit. For the moderating factors, the initial voluntariness for use was removed –consumers are seen to have more decision power than employees do when it comes to purchasing technology. Our data seem to indicate that the elderly user group cannot be considered as a totally consumer group in relation to health-related technologies. We therefore suggest adding voluntariness of use again to the model. This means that users in this market might not feel free to use a technology. At the same time, because the user group is the community-dwelling elderly living at home, we see attitude can play an important role. In other words, your doctor or spouse might want you to use a technology but your attitude towards it might stop you from obeying them. The implication is that designing technology for this user groups should involve cooperation among multiple stakeholders. In this context, habits but also price in some countries might play a larger role than what we have found in our study.

Another interesting finding is the total lack of evidence with regard to hedonic motivation. Some might explain this by referring to the age of the user group. However, our explanation is that hedonic motivation is often not regarded as relevant for healthcare in general –and in particular among the elderly population. Health-related technology is often developed to solve or contain a serious health problem. The care models behind much of this technology focus on disease management. Current care models are often blind to the realities of community-dwelling users who live at home and try to have a normal life despite having e.g. a chronic condition. Our earlier studies (Skinstad & Farshchian, 2016) show for instance that much of current ICT solutions for chronic diseases are developed to support traditional compliance-oriented care models and fail to empower patients with chronic conditions who live in the community. Hedonic motivation can play an important role if we approach health-related technologies with the aim to empower. This is currently an emerging theme, especially within the HCI community in the areas such as exergames (Skjære, et al., 2015).

Some research areas seem to be represented much more than others in our sample. This is easy to observe as we organized Sections 4.2.1 and 4.2.2 roughly based on the amount of research available in each topic. For instance, violation of privacy as a barrier has attracted a lot of interest among researchers compared to e.g. cognitive abilities. This can have many explanations, and some of them might be considered as pure speculation since we can only guess the initial motivations of the authors of the studies when they defined their research questions. However, we think this is an important issue to raise. One explanation for this imbalance can be that some of these topics are already saturated with research. Another, in our view more plausible explanation is that researcher define research questions partly based on personal interests in research topics, and partly based on available funding. Our study can help map areas that are under-researched despite their importance.

Despite how useful we might find a technology acceptance model, it is important to keep in mind that we should use such models only as a map. Our data shows that the elderly user group is not a homogeneous group. Not only does the group include vast variation in age –e.g. from 68 to 90 –but also, within each smaller age group, we find differences in attitudes and abilities to use technology. This kind of variation even problematizes the mere concept of technology acceptance[3]. We should therefore avoid using such models as a replacement for participatory design. The underlying assumption, and the design of future studies, should always focus on mapping the needs of the specific user group. (This is also the main reason why we only included literature that used the elderly user group as informants.) However, we believe good acceptance models based on empirical research have important contributions to make. For example, many researchers –including ourselves –find it difficult

[3] We thank one of the anonymous reviewers who raised this point.

to involve the elderly user group in the initial phases of a design process when the users cannot see any direct benefit. Acceptance models are useful in focusing our initial design space, hopefully making the design process more relevant for the right user groups. For practitioners alike, acceptance models can provide an initial low-threshold step to evaluate their investment in new technology. This initial phase needs to be followed up by user involvement further down in the design process.

5.1. Limitations of the study

In a systematic literature survey there are always articles that are not included. The research design is that of a survey, where only a sample from a large population is included in the study. One weakness of our study might be that the included sample is not representative enough. This might be due to limitations in the search string—e.g. we have not included some relevant keywords—or due to the fact that we have not searched in some relevant databases. We also excluded 16 articles whose PDF files were not available to us online. In our study, we had several iterations of the search string and we have searched in two major databases—Scopus and PubMed—that cover health-related and other research. However, the study can be strengthened by adding other keywords, databases and relevant articles. In order to increase transparency and allow reproducibility we provide an online resource that includes information about how we arrived at the search string, and a list of all the excluded articles (Vassli & Farshchian, 2016).

We have neither done any explicit appraisal of the methodological quality of the included papers. We have however included only peer-reviewed journal articles in our sample. We have assumed that journals indexed in Scopus and PubMed have already done proper methodology appraisal during their peer-review process. We acknowledge that more can be done in order to create a more specialized appraisal model for the type of research that we have focused on. For instance, we could have separated longitudinal studies from other studies, or we could have distinguished between evidence that is based on hands-on experiences, versus those based on subjective attitudes without hands-on experience.

We have aimed at reviewing only qualitative evidence in our study. The UTAUT2 model is mainly a quantitatively verified model. Synthesising qualitative and quantitative data together can be challenging and controversial (Mays, Pope, & Popay, 2005). Qualitative studies often focus on rich and contextual data that are difficult to synthesise with other qualitative studies, as it is common in any synthesis of quantitative data. This means that the findings from the studies we refer to, and our own conclusions based on these data, might seem vague compared to purely quantitative studies. We might have had a more rigorous study by also analysing quantitative data that are available in the included studies. For instance, we can analyse each study, looking for the number of male and female users, their age, and their experience in using ICT. At the same time, this kind of further study might also provide a false feeling of rigor because qualitative studies contain a large number of uncontrolled parameters. We believe therefore our study should be rather viewed as a preliminary qualitative study aimed at generating research questions for future quantitative studies.

5.2 Areas for future research

The study has revealed some areas for further research in the framework of UTAUT2. We see a strong influence of attitudes and underlying values and beliefs that UTAUT2 does not seem to address. Additionally, voluntariness of use that existed in UTAUT but was removed in UTAUT2 might again be relevant for health-related technologies that lie somewhere between organizational and consumer technologies. Our proposed specialization of the UTAUT2 model needs to be verified/falsified and potentially quantified in future studies.

Our study can be complemented in a number of ways. We have not included the views of close caregivers such as family members. Many family caregivers are themselves senior users, but might have different attitudes and views towards health-related technologies in their role as caregivers. Their

views are crucial to the design of these technologies. A qualitative literature review on this topic can be a useful complementary study to ours. A related future work can be to compare the needs of community-dwelling elderly –from this article –to those of other groups of elderly, for instance those living in nursing homes. This can help us stress the uniqueness of living in the community.

Another area of future work is to expand the analysis of the data we have presented in our study in different directions. Our analysis can be complemented with quantitative studies in order to strengthen some of the findings. These studies are already collected in our database (Vassli & Farshchian, 2016) but in this article we used only qualitative studies. Moreover, we can extend our study by doing analyses that are more specialized. We can for instance look into details regarding age groups, numbers of male and female users, methodologies used, etc. Another interesting area of further research would be to see what constructs in the acceptance model are important in which technology domains. For instance, we might find that personal emergency systems are useful for a group of users who feel unsafe due to fear of falling.

6. Conclusions

In this paper, we have presented our findings from a systematic literature review of the acceptance of ICT among community-dwelling elderly users. We have included qualitative studies only, in order to be able to answer some questions about how and why these users use health-related technologies. We have also included only studies that are based on first-hand data collected among the members of the elderly user group. We have presented a number of topics as motivators or barriers to use health-related technologies. We used UTAUT2 acceptance model as a framework to present and discuss the findings. Moreover, we have proposed a specialization of UTAUT2 in order to make it more useful in the area of health-related technologies for elderly living in the community. This proposal needs further research in order to verify and quantify the new features.

Our work has two main contributions. First, it provides an up-to-date summary and status of knowledge about the views of the older adults about technology. It provides a comprehensive set of topics, and summarizes what we currently know about each. Second, our work contributes to the development of a technology acceptance model for older community-dwelling adults using health-related technologies. We have provided details for some of the UTAUT2 constructs such as performance and effort expectancy. We have also proposed to extend the model with two new constructs. We believe this study can help researchers to gain better understanding of how seniors use technology. At the same time, we hope a more specialized variant of the UTAUT2 model can assist designers in making initial design decisions that are more in-line with the needs of this user group as reported in the research literature. Our long-term research goal is to create a fully operationalised and evolving acceptance model that can be used as a map for technology developers and service providers.

Living at home and community is profoundly different from living in an institution such as a nursing home or a care home. Home is a private place, and a place for nurturing social relationships with family and friends in the close community. When designing health-related technologies for home, we tend to use the institution as a model. Home-based healthcare is often looked upon as an extension of institutional care, with technologies that resemble those we find in e.g. hospitals. Similarly, the types of health services we provide at home are often distributed versions of institutional services, and tend to reduce the "patients" into data collection points. The studies we have presented in this article shed light upon the needs and concerns of seniors living at home. They show that aspects such as privacy, feeling safe, and nurturing social relationships need to play a much stronger role when developing health-related ICT for home use. Not doing so will not only result in wasted investments in technology development, but will also, eventually, convert homes into institutions.

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7. References

Alexander, G., Wakefield, B., Rantz, M., Skubic, M., Aud, M., Erdelez, S., & Ghenaimi, S. (2011). Passive sensor technology interface to assess elder activity in independent living. *Nursing Research, 60*(5), 318-325.

Alwan, M., Dalal, S., Mack, D., Kell, S., Turner, B., Leachtenauer, J., & Felder, R. (2006). Impact of monitoring technology in assisted living: Outcome pilot. *IEEE Transactions on Information Technology in Biomedicine, 10*(1), 192-198.

Ancker, J., Witteman, H., Hafeez, B., Provencher, T., Van de Graaf, M., & Wei, E. (2015). "You get reminded you're a sick person": Personal data tracking and patients with multiple chronic conditions. *Journal of Medical Internet Research, 17*(8), e202.

Campbell, R. (2008). Meeting seniors' information needs: Using computer technology. *Home Health Care Management & Practice, 20*, 328-335.

Chaudhuri, S., Thompson, H., & Demiris, G. (2014). Fall detection devices and their use with older adults: a systematic review. *Journal of geriatric physical therapy, 37*(4), 178-196.

Chen, K.-Y., Harniss, M., Patel, S., & Johnson, K. (2014). Implementing technology-based embedded assessment in the home and community life of individuals aging with disabilities: A participatory research and development study. *Disability and Rehabilitation: Assistive Technology, 9*(2), 112-120.

Chung, J., Reeder, B., Lazar, A., Joe, J., Demiris, G., & Thompson, H. (2014). Exploring an informed decision-making framework using in-home sensors: Older adults' perceptions. *Informatics in primary care, 21*(2), 73-77.

Connelly, K., Mokhtari, M., & Falk, T. (2014). Approaches to Understanding the Impact of Technologies for Aging in Place: A Mini-Review. *Gerontology, 60*(3), 282-288.

Connelly, K., Siek, K., Mulder, I., Neely, S., Stevenson, G., & Kray, C. (n.d.). Evaluating pervasive and ubiquitous systems. *Pervasive Computing, IEEE, 7*(3), 85-88.

Courtney, K. (2008). Privacy and senior willingness to adopt smart home information technology in residential care facilities. *Methods of Information in Medicine, 47*(1), 76-81.

Dahl, Y., Farshchian, B., Vilarinho, T., Helbostad, J. L., Nawaz, A., Nygård, A. J., & Wik, P. (2015). Stakeholder Attitudes Toward and Values Embedded in a Sensor-Enhanced Personal Emergency Response System. *Interacting with Computers, 28*(5), 598-611.

Damodaran, L., Olphert, W., & Phipps, S. (2013). Keeping silver surfers on the crest of a wave - Older people's ICT learning and support needs. *Working with Older People, 17*(1), 32-36.

DeJonge, K., Taler, G., & Boling, P. (2009). Independence at home: community-based care for older adults with severe chronic illness. *Clinics in geriatric medicine, 25*(1), 155-169.

Demiris, G., Hensel, B., Skubic, M., & Rantz, M. (2008). Senior residents' perceived need of and preferences for "smart home" sensor technologies. *International Journal of Technology Assessment in Health Care, 24*(1), 120-124.

Demiris, G., Oliver, D. P., Dickey, G., Skubic, M., & Rantz, M. (2008). Findings from a participatory evaluation of a smart home application for older adults. *Technology and Health Care-European Society for Engineering and Medicine, 16*(2), 111-118.

Demiris, G., Oliver, D. P., Giger, J., Skubic, M., & Rantz, M. (2009). Older adults' privacy considerations for vision based recognition methods of eldercare applications. *Technology and Health Care, 17*(1), 41-48.

Demiris, G., Rantz, M., Aud, M., Marek, K., Tyrer, H., Skubic, M., & Hussam, A. (2004). Older adults' attitudes towards and perceptions of "smart home" technologies: a pilot study. *Informatics for Health and Social Care, 29*(2), 87-94.

Demiris, G., Thompson, H., Boquet, J., Le, T., Chaudhuri, S., & Chung, J. (2012). Older adults' acceptance of a community-based telehealth wellness system. *Informatics for Health and Social Care, 38*(1), 27-36.

Dixon-Woods, M. (2006). How Can Systematic Reviews Incorporate Qualitative Research? A Critical Perspective. *Qualitative Research, 6*(1), 27–44.

Farshchian, B., & Dahl, Y. (2015). The Role of ICT in Addressing the Challenges of Age-Related Falls: A Research Agenda Based on a Systematic Mapping of the Literature. *Personal and Ubiquitous Computing*(19), 649–66.

Finkelstein, J., Knight, A., Marinopoulos, S., Gibbons, M., Berger, Z., Aboumatar, H., . . . Bass, E. (2012). Enabling patient-centered care through health information technology.

Fischer, S., David, D., Crotty, B., Dierks, M., & Safran, C. (2014). Acceptance and use of health information technology by community-dwelling elders. *International journal of medical informatics, 83*(9), 624-635.

Goodall, K., Ward, P., & Newman, L. (2010). Use of information and communication technology to provide health information: What do older migrants know, and what do they need to know? *Quality in Primary Care, 18*(1), 27-32.

Greenhalgh, T., Wherton, J., Sugarhood, P., Hinder, S., Procter, R., & Stones, R. (2013). What matters to older people with assisted living needs? A phenomenological analysis of the use and non-use of telehealth and telecare. *Social Science & Medicine, 93*, 86-94.

Gövercin, M., Költzsch, Y., Meis, M., Wegel, S., Gietzelt, M., Spehr, J., . . . Steinhagen-Thiessen, E. (2010). Defining the user requirements for wearable and optical fall prediction and fall detection devices for home use. *Informatics for health and social care, 35*(3-4), 177-187.

Hawley-Hague, H., Boulton, E., Hall, A., Pfeiffer, K., & Todd, C. (2014). Older adults' perceptions of technologies aimed at falls prevention, detection or monitoring: a systematic review. *International journal of medical informatics, 83*(6), 416-426.

Hwangbo, H., Yoon, S., Jin, B., Han, Y., & Ji, Y. (2013). A Study of Pointing Performance of Elderly Users on Smartphones. *International Journal of Human-Computer Interaction, 29*(9), 604–618.

Jaschinski, C., & Allouch, S. (2015). An extended view on benefits and barriers of ambient assisted living solutions. *International Journal on Advances in Life Sciences, 7*(1-2), 40-53.

Jimison, H., Gorman, P., Woods, S., Nygren, P., Walker, M., Norris, S., & Hersh, W. (2008). Barriers and drivers of health information technology use for the elderly, chronically III, and underserved.

Jung, M.-L., & Loria, K. (2010). Acceptance of Swedish e-health services. *Journal of Multidisciplinary Healthcare, 3*, 55-63.

Kitchenham, B., & Charters, S. (2007). *Guidelines for Performing Systematic Literature Reviews in Software Engineering.* Keele, UK: EBSE . Hentet fra http://www.dur.ac.uk/ebse/resources/Systematic-reviews-5-8.pdf

Kutz, D., Shankar, K., & Connelly, K. (2013). Making sense of mobile- and web-based wellness information technology: cross-generational study. *Journal of medical Internet research, 15*(5).

Lauriks, S., Reinersmann, A., Van der Roest, H., Meiland, F., Davies, R., Moelaert, F., . . . Dröes, R.-M. (2007). Review of ICT-based services for identified unmet needs in people with dementia. *Ageing research reviews, 6*(3), 223-246.

Loh, P.-K., Flicker, L., & Horner, B. (2009). Attitudes Toward Information and Communication Technology (ICT) in Residential Aged Care in Western Australia. *Journal of the American Medical Directors Association, 10*(6), 408-413.

Lu, J.-F., Chi, M.-J., & Chen, C.-M. (2014). Advocacy of home telehealth care among consumers with chronic conditions. *Journal of clinical nursing, 23*(5-6), 811-819.

Lynch, K. R., Schwerha, D. J., & Johanson, G. A. (2013). Development of a Weighted Heuristic for Website Evaluation for Older Adults. *International Journal of Human-Computer Interaction, 29*(6), 404-418.

Mays, N., Pope, C., & Popay, J. (2005). Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. *Journal of Health Services Research & Policy, 10*(1_suppl), 6-20.

Memon, M., Wagner, S., Pedersen, C., Beevi, F., & Hansen, F. (2014). Ambient assisted living healthcare frameworks, platforms, standards, and quality attributes. *Sensors, 14*(3), 4312-4341.

Milligan, C., Roberts, C., & Mort, M. (2011). Telecare and older people: Who cares where? *Social Science & Medicine, 72*(3), 347-354.

Mostashari, F. (2011). *Aging in place: the national broadband plan and bringing health care technology home.* Technical report. Statement to the Senate Special Committee on Aging and the United States House of Representatives by the Senior Advisor to the Office of the National Coordinator for Health IT. Retrieved from http://www.hhs.gov/asl/testify/2010/04/t20100422e.html

Parker, S., Jessel, S., Richardson, J., & Reid, M. (2013). Older adults are mobile too! Identifying the barriers and facilitators to older adults' use of mHealth for pain management. *BMC Geriatrics, 13*(1), 43.

Pietrzak, E., Cotea, C., & Pullman, S. (2014). Does smart home technology prevent falls in community-dwelling older adults: a literature review. *Source of the DocumentInformatics in Primary Care, 21*(3), 105-112.

Price, M., Pak, R., Müller, H., & Stronge, A. (2013). Older adults' perceptions of usefulness of personal health records. *Universal access in the information society, 12*(2), 191-204.

Procter, R., Greenhalgh, T., Wherton, J., Sugarhood, P., Rouncefield, M., & Hinder, S. (2014). The Day-to-Day Co-Production of Ageing in Place. *Computer Supported Cooperative Work, 23*(3), 245-267.

Reeder, B., Chung, J., Le, T., Thompson, H., & Demiris, G. (2014). Assessing Older Adults' Perceptions of Sensor Data and Designing Visual Displays for Ambient Assisted Living Environments: An Exploratory Study. *Methods of information in medicine, 53*(3), 152-159.

Rios, G. (2013). eHealth literacy and older adults: A review of literature. *Topics in Geriatric Rehabilitation, 29*(2), 116-125.

Romano Bergstrom, J. C., Olmsted-Hawala, E. L., & Jans, M. E. (2013). Age-Related Differences in Eye Tracking and Usability Performance: Web Site Usability for Older Adults. *International Journal of Human-Computer Interaction, 29*(8), 541-548.

Sanders, C., Rogers, A., Bowen, R., Bower, P., Hirani, S., Cartwright, M., . . . Newman, S. (2012). Exploring barriers to participation and adoption of telehealth and telecare within the Whole System Demonstrator trial: A qualitative study. *BMC Health Services Research, 12*(1), 220.

Sayago, S., & Blat, J. (2011). An ethnographical study of the accessibility barriers in the everyday interactions of older people with the web. *Universal Access in the Information Society, 10*(4), 359-371.

Sjölinder, M., & Avatare Nöu, A. (2014). Indoor and outdoor social alarms: understanding users' perspectives. *JMIR mHealth and uHealth, 2*(1).

Skinstad, T. J., & Farshchian, B. (2016). Empowerment or concealed compliance? A review of literature on mobile ICT solutions for patient empowerment. *Proceedings of ACM PETRA* (s. xx). Island of Corfu, Greece: ACM.

Skjære, N., Nawaz, A., Ystmark , K., Dahl, Y., Helbostad, J. L., Svanæs, D., & Vereijken, B. (2015). Designing for Movement Quality in Exergames: Lessons Learned from Observing Senior Citizens Playing Stepping Games. *Gerontology , 61*(2), 186-194 .

Slade, E., Williams, M., & Dwivedi, Y. (2013). An extension of the UTAUT 2 in a healthcare context. *Proceeding of the UK Academy for Information Systems*.

Steele, R., Lo, A., Secombe, C., & Wong, Y. (2009). Elderly persons' perception and acceptance of using wireless sensor networks to assist healthcare. *International journal of medical informatics, 78*(12), 788-801.

Trief, P., Sandberg, J., Izquierdo, R., Morin, P., Shea, S., Brittain, R., . . . Weinstock, R. S. (2008). Diabetes management assisted by telemedicine: Patient perspectives. *Telemedicine and e-Health, 14*(7), 647-655.

United Nations. (2015). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables.* New York: United Nations.

Vassli, L., & Farshchian, B. A. (2016, May 1). Background material for systematic review of literature on ICT acceptance among community dwelling elderly. doi:10.5281/zenodo.50293

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly, 36*(1), 157-178.

Wagner, F., Basran, J., & Dal Bello-Haas, V. (2012). A review of monitoring technology for use with older adults. *Journal of geriatric physical therapy, 35*(1), 28-34.

Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. (2011). Using Grounded Theory as a Method for Rigorously Reviewing Literature. *European Journal of Information Systems*, 1–11.

Wu, Y.-h., Damnée, S., Kerhervé, H., Ware, C., & Rigaud, A.-S. (2015). Bridging the digital divide in older adults: A study from an initiative to inform older adults about new technologies. *Clinical Interventions in Aging, 10*, 193-201.

Yang, K., & Jolly, L. D. (2008). Age Cohort Analysis in Adoption of Mobile Data Services: Gen Xers versus Baby Boomers. *Journal of Consumer Marketing, 25*(5), 272–80.

Young, R., Willis, E., Cameron, G., & Geana, M. (2014). "Willing but Unwilling": Attitudinal barriers to adoption of home-based health information technology among older adults. *Health Informatics Journal, 20*(2), 127-135.

Yu, T.-K., & Chao, C.-M. (2014). Assessing Older Adults' Information Technology Ability: The Development of a Multiple Item Scale. *International Journal of Human-Computer Interaction, 30*(6), 435-445.

Zhou, J., Rau, P.-L., & Salvendy, G. (2014). Older adults' text entry on smartphones and tablets: Investigating effects of display size and input method on acceptance and performance. *International Journal of Human-Computer Interaction, 30*(9), 727-739.

Biographies of the authors

Lars Tore Vassli is a developer at the Trondheim Municipality in Norway. He has a MSc degree in Informatics from the Norwegian University of Science and Technology. Lars studied at NTNU when writing this article. He is interested in HCI and software solutions that can demonstrate high acceptance among users.

Babak Farshchian is a senior scientist at SINTEF and an adjunct associate professor at NTNU. Babak's interests include mobile and ubiquitous computing, collaborative technologies, and user-centred design. Babak's research is about how information technologies can affect user empowerment. Babak in involved in projects with elderly and people with special needs.

Appendix

AND →

OR ↓

INTERVENTION	PURPOSE	USER	TECHNOLOGY	EXCLUSION
Acceptance	Healthcare	Elderly	ICT	Hospital
Willingness	Health care	Seniors	Information technology	Nursing home
Usability	Health-related	Senior citizens	Smartphone	Institution
Perception	Well-being	Aged population	Wearable	
Perceptive behaviour	Independence	Aging population	Mobile	
Attitude	Autonomy	Old people	Phone	
Ease of use	Comfort	Old adults	Sensor	
Easy to use	Happiness	Older adults	Telemedicine	
Approval	Welfare	Old age	Pervasive	
Concern	Aging in place	Elders	Ubiquitous	
Satisfaction	Geriatrics		Wireless sensor network	
Human-computer interaction	Gerontology		WSN	
HCI			Smartwatch	
Acceptability			Activity tracker	
User experience			Fitness wristband	
User-experience			Activity monitoring device	
Perceived value			Health information technology	
Human factors			Health IT	
Barriers			Ambient Assisted Living	
			Smart home	
			E-health	

Table 1: Search query

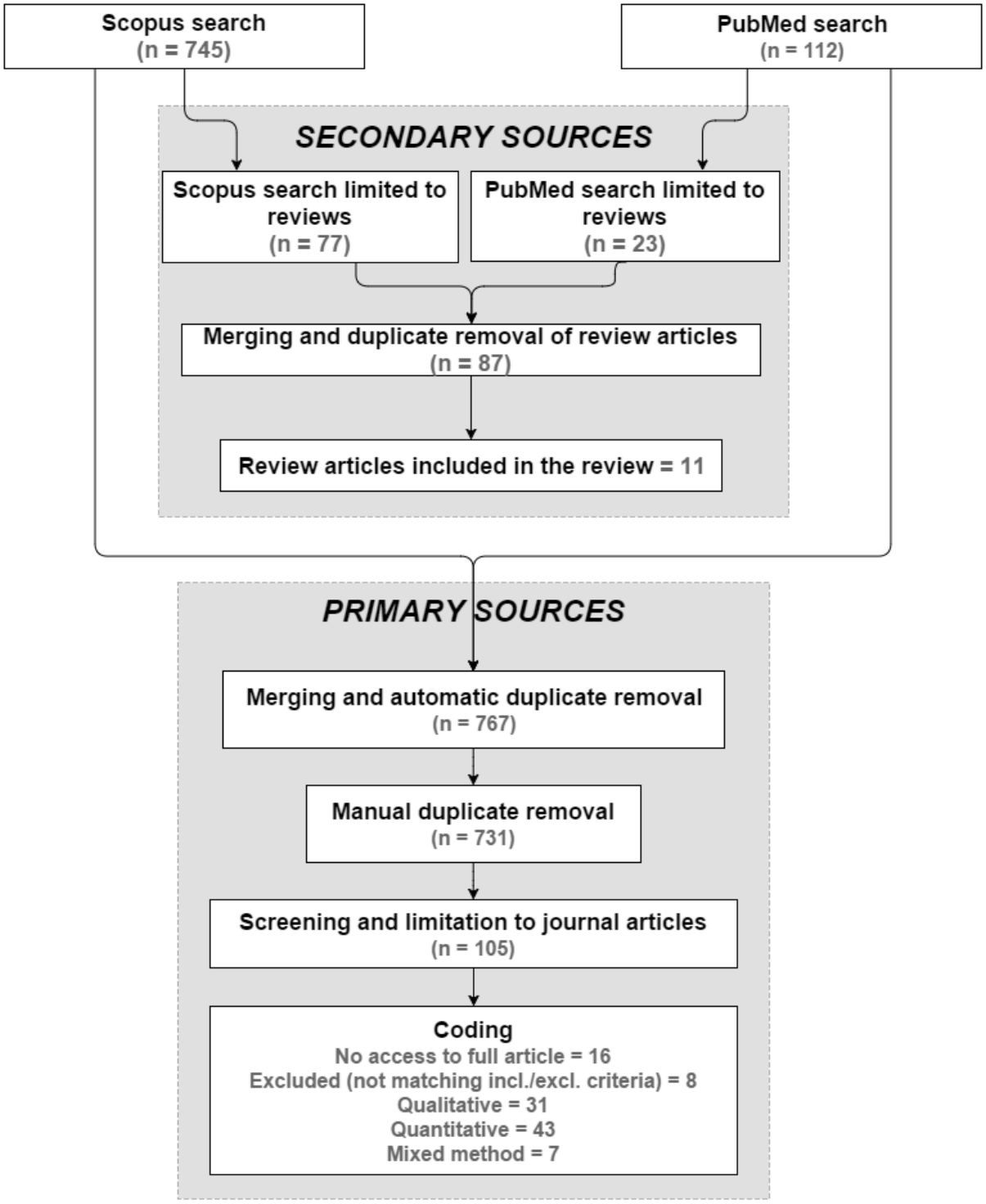

Figure 3: Diagram of search strategy

INCLUSION CRITERIA	EXCLUSION CRITERIA
It is a literature review, presenting the findings from multiple primary sources.	The review is addressing elderly people not living in the community (e.g. living in nursing home, institution, hospital).
The review investigates the acceptance of health and well-being ICT.	It reviewed sources that are not research papers (e.g. commentary, editorial, workshop summary, expert opinion, conference proceeding).
The review focuses on elderly people.	Duplicate (not detected by bibliography software).
The review is published in English.	Unable to gain access to online version of full article.
The findings in the review must be based on empirical evidence.	

Table 2: Inclusion/exclusion criteria for the secondary sources.

INCLUSION CRITERIA	EXCLUSION CRITERIA
It is a research paper, reporting on a specific study of using ICT.	The research is addressing elderly people not living in the community (e.g. nursing home, institution, hospital).
The research investigates the acceptance of health and well-being ICT.	It is not a journal paper (e.g. it is a commentary, editorial, workshop summary, expert opinion, conference proceeding).
The research focuses on elderly people and data relevant for acceptance is collected from elderly people.	The research is on acceptance but is not based on empirical data collected from elderly.
The research is published in English.	Duplicate (not detected by bibliography software).
The findings in the research must be based on empirical evidence.	Unable to gain access to online version of full article.
The research is qualitative.	
The research is published as a journal article.	

Table 3: Inclusion/exclusion criteria for the primary sources.

Title	Focus on elderly	Focus on ICT	Focus on acceptance of ICT	Reviews data collected from elderly people	Looks at the general use of ICT in healthcare *(not at a specific intervention)*	Looks at ICT in general *(not a specific type of ICT)*	Systematic literature review
A Review of Monitoring Technology for Use With Older Adults (Wagner et al., 2012)	Yes	Yes	Partially	No	No *(fall detection and health monitoring)*	No *(monitoring tech)*	No
Acceptance and use of health information technology by community-dwelling elders (Fischer et al., 2014)	Yes	Yes	Yes	Yes	Yes	Yes	No
Ambient Assisted Living healthcare frameworks, platforms, standards, and quality attributes (Memon, Wagner, Pedersen, Beevi, & Hansen, 2014)	Yes	Yes	Partially	Yes	Yes	No *(AAL)*	No
Approaches to understanding the impact of technologies for aging in place: A mini-review (Connelly, Mokhtari, & Falk, Approaches to	Yes	Yes	Yes	No	Yes	Yes	No
Barriers and drivers of health information technology use for the elderly, chronically ill, and underserved (Jimison, et al., 2008)	Yes	Yes	Yes	Yes	Yes	Somewhat *(interactive consumer health IT)*	Yes
Does smart home technology prevent falls in community-dwelling older adults: a literature review (Pietrzak, Cotea, & Pullman, 2014)	Yes	Yes	Partially	Yes	No *(fall detection and prevention)*	No *(smart home and monitoring*	No
eHealth literacy and older adults: A review of literature (Rios, 2013)	Yes	Yes	Partially	Yes	No *(eHealth literacy)*	Yes	No
Enabling patient-centered care through health information technology (Finkelstein, et al., 2012)	Yes	Yes	Partially	Yes	Somewhat *(Patient-centered care)*	Yes	Yes
Fall detection devices and their use with older adults: A systematic review (Chaudhuri, Thompson, & Demiris, 2014)	Yes	Yes	Yes	Yes	No *(fall detection)*	No *(fall detection devices)*	Yes
Older adults' perceptions of technologies aimed at falls prevention, detection or monitoring: a systematic review (Hawley-Hague et al., 2014)	Yes	Yes	Yes	Yes	No *(falls prevention, detection and monitoring)*	Yes	Yes
Review of ICT-based services for identified unmet needs in people with dementia (Lauriks, et al., 2007)	Yes	Yes	Yes	Yes	No *(dementia)*	Yes	No

Table 4: Overview of and relevance of included literature reviews

Title	Ref.	Year
Acceptance of Swedish e-health services	(Jung & Loria, 2010)	2011
Advocacy of home telehealth care among consumers with chronic conditions	(Lu, Chi, & Chen, 2014)	2014
An ethnographical study of the accessibility barriers in the everyday interactions of older people with the web	(Sayago & Blat, 2011)	2011
An extended view on benefits and barriers of ambient assisted living solutions	(Jaschinski & Allouch, 2015)	2015
Assessing older adults' perceptions of sensor data and designing visual displays for ambient environments	(Reeder, Chung, Le, Thompson, & Demiris, 2014)	2014
Attitudes Toward Information and Communication Technology (ICT) in Residential Aged Care in Western Australia	(Loh, Flicker, & Horner, 2009)	2009
Bridging the digital divide in older adults: A study from an initiative to inform older adults about new technologies	(Wu, Damnée, Kerhervé, Ware, & Rigaud, 2015)	2015
Defining the user requirements for wearable and optical fall prediction and fall detection devices for home use	(Gövercin, et al., 2010)	2010
Diabetes management assisted by telemedicine: Patient perspectives	(Trief, et al., 2008)	2008
Elderly persons' perception and acceptance of using wireless sensor networks to assist healthcare	(Steele, Lo, Secombe, & Wong, 2009)	2009
Exploring an informed decision-making framework using in-home sensors: Older adults' perceptions	(Chung, et al., 2014)	2014
Exploring barriers to participation and adoption of telehealth and telecare within the Whole System Demonstrator trial: A qualitative study	(Sanders, et al., 2012)	2012
Findings from a participatory evaluation of a smart home application for older adults	(Demiris, Oliver, Dickey, Skubic, & Rantz, 2008)	2008
Impact of monitoring technology in assisted living: Outcome pilot	(Alwan, et al., 2006)	2006
Implementing technology-based embedded assessment in the home and community life of individuals aging with disabilities: A participatory research and development study	(Chen, Harniss, Patel, & Johnson, 2014)	2014
Indoor and outdoor social alarms: understanding users' perspectives	(Sjölinder & Avatare Nöu, 2014)	2014
Keeping silver surfers on the crest of a wave - Older people's ICT learning and support needs	(Damodaran, Olphert, & Phipps, 2013)	2013
Making sense of mobile- and web-based wellness information technology: cross-generational study	(Kutz, Shankar, & Connelly, 2013)	2013
Meeting seniors' information needs: Using computer technology	(Campbell, 2008)	2008
Older adults are mobile too! Identifying the barriers and facilitators to older adults' use of mHealth for pain management	(Parker, Jessel, Richardson, & Reid, 2013)	2013
Older adults' acceptance of a community-based telehealth wellness system	(Demiris, et al., 2012)	2013
Older adults' attitudes towards and perceptions of "smart home" technologies: a pilot study	(Demiris, et al., 2004)	2004
Older adults' perceptions of usefulness of personal health records	(Price, Pak, Müller, & Stronge, 2013)	2013
Older adults' privacy considerations for vision based recognition methods of eldercare applications	(Demiris, Oliver, Giger, Skubic, & Rantz, 2009)	2009
Passive sensor technology interface to assess elder activity in independent living	(Alexander, et al., 2011)	2011
Privacy and senior willingness to adopt smart home information technology in residential care facilities	(Courtney, 2008)	2008
Senior residents' perceived need of and preferences for "smart home" sensor technologies	(Demiris, Hensel, Skubic, & Rantz, 2008)	2008

Title	Ref.	Year
Use of information and communication technology to provide health information: What do older migrants know, and what do they need to know?	(Goodall, Ward, & Newman, 2010)	2010
What matters to older people with assisted living needs? A phenomenological analysis of the use and non-use of telehealth and telecare	(Greenhalgh, et al., 2013)	2013
Willing but Unwilling: Attitudinal barriers to adoption of home-based health information technology among older adults	(Young, Willis, Cameron, & Geana, 2014)	2014
You get reminded you're a sick person: Personal data tracking and patients with multiple chronic conditions	(Ancker, et al., 2015)	2015

Table 5: List of included primary sources