Telecare services for aging people:
Assessment of critical factors influencing the adoption intention

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ABSTRACT

The dimensions of telecare services are analyzed and contrasted to theories of behavioural intentions. Factors influencing the adoption of innovations are derived from target group specific factors and telecare features. We present results from an empirical study which interlinks users’ characteristics, technology and the intention to adopt technology based services. We examine customers above 55 years of age in terms of their physical, psychological and cognitive limitations. The central objective is to assess how these differences influence the potential usage of telecare services. A mail survey was conducted in a medium-sized city to collect data. The target population was slightly over 9 000 persons of which a randomized sample (N=1000) was gathered. A total of 506 usable responses were obtained for analysis. The results indicate that the adoption behavior of individuals differs amongst potential telecare users. Indeed, the behavioral patterns do not remain constant over time. Therefore, understanding the context of use has particular importance in the design phase of telecare services.

Keywords: telecare; aging consumers; electronic services; adoption intention
1 Introduction

In order to reduce pressures that modern societies face in their health and social care, the potential of technology-based services has widely been accepted amongst academics and practitioners. Particularly customer-driven telecare, telehealth and other e-services for aging people has been in pivotal role when new concepts have searched to improve performance of public health system. A significant amount of research focuses on evaluate different technologies enabling a longer span of living at home whilst the other side of the debate provides discourse on the general needs of aging people. Regardless of the numerous articles published, there is still room for research which aims to analyse the applicability of e-service concepts for specific user groups and to determine the boundaries of the domain of telecare within health care systems.

Telecare can be defined as a service bringing health and social care directly to a service user, generally in their own homes, supported by information and communication technology (Barlow, Curry, Wardle, Bayer, & Trejo Tinoco, 2004). Telecare is meant to support the independent living and welfare of the elderly or people with disabilities. It involves the delivery of health and social care to individuals to their home or a wider community outside formal institutional settings, with the support of systems enabled by information and communication technology (Bayer, Barlow, & Curry, 2007). Based on the work of Barlow et al. (2004), the content of telecare includes safety and security monitoring, personal monitoring, electronic assistive technology, and information and communication solutions which also involve interaction.

Aging people’s need of support varies significantly between individuals and even day to day in one’s life. Individuals’ perceptions of their abilities to continue independent living at home can, however, be improved through appropriate technology interventions and by redesigning the living environment. A sufficiently adapted living environment with regard to ones functional capabilities has potential to motivate senior citizens to perform challenging activities for as long as possible (Fänge & Ivanoff, 2009). Overall, an appropriately designed environment gives an experience of self-efficacy to continue living independently. Self-care technologies that fit into daily routines and are logical and reliable in use are considered critical features of efficient technology interventions in elderly care (LeRogue, Ma, Sneha & Tolle 2011). The successful design of services begins from understanding the routines of the elderly to which service processes and interfaces are adapted. Therefore, one general solution cannot be defined, which is a major concern of service design requiring flexible and modular design.

The distress of individuals and care givers, and costly medical treatments in case of accidents are the most significant concerns that physically or cognitively restricted senior citizens and their relatives face (Monk et al., 2006). Technology interventions have the potential to decrease the adverse consequences of limited functionality particularly in the area of cognitive restrictions, enabling people with mild dementia to prolong the period of living at home (Davies et al., 2009). Disability processes of frail persons can be moderated by supportive technologies but it is not straightforward solution. Recent studies have shown that ADL (activities of daily living)
disability significantly correlates with depression and cognitive impairment, which is likely increase anxiety to the use of technology (Kondo, Kazama, Suzuki, & Yamagata, 2008). As new technologies are developed, it is important to explore the ability and willingness of customers to use them (Meuter, Ostrom, Bitner, & Roundtree, 2003), and also apply existing technologies to services. To make technology useful and available to older adults, the research and design community must know the user and better understand the needs, preferences and abilities of older people (Czaja & Lee, 2007).

In this article, we examine customers above 55 years of age, and especially how they differ regarding their physical, psychological and cognitive limitations. The central objective is to assess how these differences influence the potential usage of telecare services. The article provides empirical evidence to debate on future role of telecare and critical view to applicability of e-solutions in health care which we expect to provide new insights for technology developers. Further, we connect demand-based customer segmentation to the analysis of the critical features of the home care service, which will have a more important position in the elderly care sector in the future.

First, the article begins with a discussion on the platforms of smart home services, aiming to shed light on the dimensions of the analyzed service concept which applies novel technologies. Second, the main theories of behavioral intentions are briefly referred to and the factors that influence the adoption of innovations are selected based on the target group and also in relation to the nature of the telecare services. Third, we present the results of an empirical study which interlinks the users’ characteristics, technology and the intention to adopt technology based services.

2 Smart homes as service delivery platforms

The service delivery system can be understood as the unified model of a network where several actors produce value to the customer and each other (Normann & Ramírez, 1993), and it contains the architecture of the product, service and information streams between actors. This is the starting point for beginning the critical review of the e-based solutions for health care. In particular, the discussion targets to assess end-user related issues which influence the implementation of smart home constructs. Regardless of the current interest in smart homes and ubiquitous solutions, no common definition for them exists at the moment. Based on the definition of a service provision model, the smart home concept (see Figure 1) can be considered as a bundle of technologies, requisite services, and information and service provision resources which are delivered by a network of firms with different resources.
The figure illustrates that smart homes can be approached from at least two viewpoints. The concepts can be defined either as smart solutions in homes to support daily living or as solutions with the primary purpose to provide a comfortable home environment. Furthermore, some authors have provided more specific definitions regarding smart home concepts (see Table 1).
Table 1. Definitions for smart homes

<table>
<thead>
<tr>
<th>Source</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chan et al., 2009</td>
<td>Any living or working environment that has been carefully constructed to assist people in carrying out required activities.</td>
</tr>
<tr>
<td>Cook and Das, 2007</td>
<td>Acquires and applies knowledge about the environment and its inhabitants in order to improve their experience in that environment.</td>
</tr>
<tr>
<td>Peine, 2009</td>
<td>Built entities in which various products and services interoperate by means of Information &amp; Communication Technologies (ICT) to constitute a product environment.</td>
</tr>
<tr>
<td>Demiris, Oliver, Dickey, Skubic, and Rantz, 2008</td>
<td>Uses sensors and other devices and telecommunication features to enhance residents’ safety and monitor their health and overall well-being.</td>
</tr>
<tr>
<td>Nugent, Finlay, Fiorini, Tsumaki, and Prassler, 2008</td>
<td>Monitors the activities of the person within their own living environment along with how they interact with home automation devices, and based upon these interactions and their current sequence of activities the ambient environment can be controlled and adapted to provide an improved living experience for the person.</td>
</tr>
</tbody>
</table>

The fundamental design strategies of smart home technologies and services can be divided into two categories form the elderly care perspective. The first category is self-care technologies which aim to enhance individuals' self-confidence regarding their ability to perform desired tasks. This is a particularly important factor in delaying the decline of activity in the elderly (Fänge & Ivanoff, 2009; Brokel, Cole, & Upmeyer, 2011). The second category includes telecare solutions designed to compensate a declined capacity to perform daily routines safely, including assistive devices, modifications in the home environment and increasing senior citizens’ awareness of alternatives for the performance of tasks (Monk et al. 2006). These aspects are discussed in the following chapters.

3 Technology based services in elderly care

3.1 Contexts of use

The design of smart homes is dependent upon personal needs and the purpose of the acquired system through which requisite services and devices are to be selected. In general, use of ICT in older age segments has an important role in three particular contexts (Salovaara, Lehmuskallio, Hedman, Valkonen, & Näätänen, 2010):
managing life transitions and maintaining social networks (e.g. retirement, moving to a new home);

(ii) overcoming transient events;

(iii) organizing daily tasks differently.

The first context includes activities which are targeted to provide easy access to the community, including, for instance, messaging services and peer groups, friends and families. However, face-to-face human contacts should be fostered regardless of smart homes because technology does not eliminate feelings of isolation from the surrounding community. Some studies have suggested that in the worst case, technology highlights the social distance of senior citizens from the surrounding community, and in the best case, novel solutions reduce isolation, enabling to stay in touch with friends and family (Salovaara et al., 2010; Dickinson & Gregor, 2006). Skepticism regarding the applicability of technology-based solutions is likely to arise particularly if the outcomes are judged from the perspective of a customer segment which needs support more than the average person in older age segments. The support activities of a smart home environment are linked to the second and third contexts where the services and devices address the functional restrictions of individuals either temporarily or permanently. The final portfolio of smart home services varies between user groups. Each solution must be tailored to fit the customer’s individual needs which can be evaluated in terms of the desired physical, cognitive, functional and social outcomes of the technology intervention and how the technology fits the end-user’s daily routines (Matthews et al., 2010). To this end, it is worth noticing the importance of daily routines for an individual’s health. Studies have shown that the ability to perform daily routines is an early indicator of increasing old age related disablement before diseases are clinically diagnosed (Fänge & Ivanoff, 2009). Technology interventions have several effects in the early stages of disablement. Technology can remove some obstacles to the functionality of people with disabilities or restore functionality to the requisite level. In fact, the onset of disablement process can be prevented amongst those with temporary ones by technology interventions. Therefore, most of the potential of smart homes involves solutions that are directed to enhance the functionality of senior citizens who shows early signs of disablement. Because early indicators of disablement differ between people, implementing smart home solutions on a large scale requires finished concepts and mass customization of platforms.

3.2 Theoretical background and hypothesis for the adoption intention of telecare services

Consumers’ willingness to adopt new services can be done by analyzing the market due to individuals’ behavioral intention to adopt or start using new services. The motivation of studying behavioral originates from the theory of planned behavior (TPB) (Ajzen, 1991) and the technology acceptance model (TAM) (Davis, 1985) which both are based on the premise that...
intention is a good predictor of actual behavior. These theories have been widely used, modified, and complemented in innovation adoption research depending on the research target.

3.2.1 Service innovation related characteristics

The adoption of an innovation depends on how attitudes are influenced by individual perceptions of the characteristics of the innovation. Based on the perceived innovation characteristics, the perceived usefulness from TAM has often been used when modeling consumer intentions. According to Salovaara et al. (2010), the willingness of senior citizens to apply technology depends strongly on its perceived usefulness. In practice, the contribution of technology to issues in daily life is considered a critical factor for acceptance (Mitzner et al., 2010; Heart & Kalderon, 2011). The perceived usefulness of technology in the analyzed context is defined through one’s ex-ante judgment of the perceived benefits of use which are dependent on skills to use ICT in daily life, previous experiences of technology use and one’s attitude to technology. Recent studies on ICT use in older age segments have shown that economic aspects may not be a significant factor in explaining the adoption of new technologies if the benefits of technology for a user are well demonstrated (Heart & Kalderon, 2011). However, economic reasons are reported to create obstacles to access to ICT among low income elderly, which can probably be influenced by developing governmental subsidies or other forms of financial support (Lee, Chen, & Hewitt, 2011; LeRouge et al., 2011; Carpenter & Buday, 2007). In the case of electronic services, previous research has verified that perceived usefulness is an important element defining intentions to adopt new services (e.g. Gefen, Karananna, & Straub, 2003a; Chan & Lu, 2004; Hong, Thong & Tam, 2006), and therefore, the first proposed hypothesis is:

Hypothesis 1: Perceived usefulness increases the intention to adopt telecare services.

Electronic services related to health always entail the transmission of personal information, which can be considered to raise questions of risks related to service reliability and privacy protection. Perceived risk can take many forms, depending on the product and consumer characteristics (Chan & Lu, 2004), and according to Walker and Johnson (2006), perceived risk has two main elements related to technology enabled services. The first concerns the technical performance or functional reliability of the service delivery systems, and the second concerns issues of personal privacy and security. These are related to the absence of human contact during the service delivery process and the performance of the service delivery system. In contrast to the perception of risk, research has shown that in the internet environment perceived trust toward the counterpart is important for behavioral intentions (Gefen et al., 2003a; Gefen, Karahanna, & Straub, 2003b). When considering consumers using electronic health care services, their perceptions of information security can be suggested to prompt adoption or rejection. Previous research discusses information security under the concepts of perceived reliability, security and privacy. For instance, privacy attached to online shopping as defined by Vijayasarathy (2004)
means the extent to which a consumer believes that shopping online will not compromise his or her privacy, and security the extent to which a consumer believes that making payments online is secure. This type of concern related to privacy is essential for online health services whether or not payments are included. The reliability aspect was referred to in the study of Lee, Lee and Eastwood (2003) as the degree to which a consumer believes that a new technology will perform a job consistently and accurately. In the same study, perceived security indicated concerns about transaction security in terms of cyber crime or errors in transactions. This type of security includes the aspects of feeling safe when transmitting personal information through the network, and is thus important for the present study. Including privacy concerns, the second hypothesis is:

**Hypothesis 2: Perceived reliability increases intentions to adopt telecare services.**

### 3.2.2 Personal attitudes related to ICT

In outline, the adoption of e-services has two core parts: the service itself (which has already been discussed) and the device through which the service is used. The attitudes and perceptions toward the service influence the adoption decision, but also the attitudes and perceptions related to the devices are important because the target market has to have the necessary knowledge and capabilities that are required for reaching the maximum benefits of the service. Considering aging people as the target market for a new e-health application, it has to be born in mind that this population has grown in a world without computers, mobile phones or the Internet. In addition, a large share of elderly consumers was not acquainted with these technologies in their profession, and therefore, learning how to use the required technologies is based on voluntary choices. Senior citizens adopting innovations typically fear that the innovations will not perform as desired (Lunsford & Burnett, 1992). This type of functional risk increases along with the technological complexity of the innovation. Among older consumers and technology, a common issue under research is the fear of technology, i.e. technology anxiety. According to Meuter et al. (2003), technology anxiety focuses on the user's state of mind regarding their ability and willingness to use technology-related tools. In information technology research, the focus has been on computer anxiety. According to Izard and Tomkins (1966), anxiety in general can be seen as a negative affect that tends to be sensed as noxious and difficult to tolerate and to instigate avoidance of and/or nonconstructive relations with the object. Technology anxiety originates from computer anxiety, which has been defined as emotional fear, apprehension and phobias felt by individuals towards interactions with computers or when they think about using computers (Chua, Chen, & Wong, 1999). It refers to negative attitudes toward using a computer. The anxiety is likely to arise from the inability or lack of self-confidence in effectively managing or controlling the technology (Oyedele & Simpson, 2007). Attitudes towards computers at a general level have appeared to be good predictors of understanding of and experience in computers (Potosky & Bobko, 2001), and it also decreases the subjects’ expectations and
confidence regarding the performance of computer related tasks (Glass & Knight, 1988). Therefore, technology anxiety is a remarkable factor in how likely an individual user judges the new technology-based services useful and valuable. Former experiences in the use of the Internet have consistently proven to correlate with computer anxiety in older age segments, providing a method to evaluate the behavior of an individual (Niemelä-Nyrhinen, 2007). Technology anxiety concerning devices used for e-services can therefore be seen as an inhibitor to the adoption of new services. On the other hand, suspicious attitudes related to computers might also complicate the perceptions related to usefulness and especially the reliability of services, and therefore it is hypothesized that:

**Hypothesis 3:** Technology anxiety decreases the perceived usefulness of telecare services.

**Hypothesis 4:** Technology anxiety decreases the perceived reliability of telecare services.

Considering that ICT might be quite novel for the aging consumer, the avoidance of technology might also be related to the design and interface of the device in terms of physical elements. Behavioral intention in TPB includes a determinant of perceived behavioral control that refers to people’s perception of the ease or difficulty of performing the behavior of interest (Ajzen, 1991) and derives from control beliefs and facilitation. Besides attitudinal control related to a person’s knowledge, the physical capabilities of an aging individual cannot be neglected. The lack of these capabilities may rise, for example, from physical impairment or poor sight, and can therefore form physical restrictions that decrease the willingness to use ICT or even make the use of ICT completely impossible. Persons with disabilities have proven to lack the intension to adopt ICT because of lower perceived behavioral control over ICT due to physical restrictions (Heart & Kalderon, 2011). Therefore, smart home system interfaces should not include numerous visible options, their functions should not require complex tasks and their overall design should emphasize intuitive activities. The device dependent physical limitations are therefore assumed to decrease the intention to adopt e-services and decrease the level of usefulness and reliability related to the services. Thus, the hypotheses are:

**Hypothesis 5:** Physical restrictions decrease the perceived usefulness of telecare services.

**Hypothesis 6:** Physical restrictions decrease the perceived reliability of telecare services.
3.2.3 Individual characteristics of the elderly

Aging has psychological, biological, social and economic influences on consumers (see Pak & Kambil, 2006). Biological changes cover changes in mobility, vision and hearing, which all influence daily customs. For service developers, the biological issues create challenges for product and service design and communication methods. Changes in memory and information processing result in a declining rate of learning and avoiding situations that are not familiar. People age differently and aging itself is a multidimensional process. Differences in consumer responses among older people are not likely to be the result of any specific factor, and the processes of aging are manifest in differences in attitudes and behaviors even among people of the same age (Moschis, 1992). Research has found that neither cognitive nor chronological age are determinants of innovativeness among the elderly (Szmigin & Carrigan, 2000). Vuori and Holmlund-Rytönen (2005) found similar results in their study on Internet users over 55 years of age. Cognitive age had no relationship with Internet use; instead, health was found to be a predictor of Internet use. As the need for care services is strongly bound to the perception of health and functioning, the aging market is divided into high need consumers (the elderly in poor health) and low need consumers (the well-coping elderly). Hence, the final hypotheses are:

**Hypothesis 7:** Personal attitudes related to ICT have a weaker effect on service perceptions among the well-coping elderly.

**Hypothesis 8:** Service perceptions have a stronger influence on intention to adopt telecare services among the well-coping elderly.

4 Method

4.1 Sample and demographics

The empirical evidence was collected in a cross-sectional mail survey that was targeted to 55–79-year-old inhabitants in a medium-sized city located in South-East Finland. The total target population was slightly over 9 000 persons. A stratified random sample of 1 000 people was drawn from the Finnish Population Register. The sample frame was based on the population age distribution divided into five-year categories. A total of 556 responses were received and the resulting age distribution was representative, indicating no statistical difference compared to the true age distribution in the population (Figure 2). The gender distribution was also in line with the target population; the share of female respondents was 56.8 percent (54.4 in the overall population). Due to incomplete responses, the effective sample used in the analysis was 506. The
data consisted mainly of individuals living independently in the community, as only 1.5 percent received public home care assistance. The share was the same in the target population.

Figure 2. Age distribution of the respondents versus the population

4.2 Research model, key concepts and measurement

Figure 3 illustrates the research model including the hypotheses and thus also gathers together the key concepts essential for the empirical study.

Figure 3. Key concepts and research model

The measurement included multi-item scales that were mainly gathered from previous literature and modified to fit the content of the research. The scales were kept as short as possible in order
to make the questionnaire easier to fill out and to prevent frustration. All items (if not otherwise reported) were statements measured with a 5-point Likert scale varying from complete disagreement to complete agreement.

**Health and functioning** was included for the purposes of dividing the elderly into two groups. This actually covered a self-rated health status, cognitive functioning and functional ability.

**Functional ability** was measured using similar methods as in a previous study (Verbrugge & Yang, 2002), including the basic activities and instrumental activities of daily living. The items were measured with a three point ordinal scale (1=cannot cope at all, 2=has difficulties, 3=copes independently). Eventually, the scale of functioning was composed of five indicators of coping with instrumental activities of daily living (small repairs, shopping, house cleaning, cooking and washing) due to the low variance in the basic activities of daily living.

**Self-rated health** was measured with a global measure for self-rated health (Jelicic & Kempen, 1999; Vaez, Kristenson, & Laflamme, 2004). It had five response alternatives varying from poor to excellent. This measure of self-rated health is non-comparative and indicates the perception of one’s current state of health. It is widely used in research on self-rated health. In order to create a multi-item scale and thus increase the reliability compared to a single item measurement, the global measure of self-rated health was complemented with three additional statements.

**Cognitive ability** was considered important for the purposes of this research because information technology based service requires learning and memory capabilities. Two measurement items selected to cover the level of cognitive capacity were drawn from the cognitive factor of the Zung Self-Rating Depression Scale (Passik et al., 2000).

**Technology anxiety** related to ICT was measured with items modified from computer anxiety. Different scales of computer anxiety and attitudes toward computers were compared in order to elaborate an effective but reasonably short and valid measurement for technology anxiety. The four selected items covered such elements as fear, discomfort and embarrassment that have been part of the scales used in previous research (e.g. Loyd & Gressard, 1984; Loyd & Loyd, 1985; Cohen & Waugh, 1989; Brock & Sulsky, 1994; Kinzie, Delcourt, & Powers, 1994; Selwyn, 1997; Shaft, Sharfman, & Wu, 2004).

Perceived **physical restrictions** for using ICT were reflected with two items, which discussed the usage difficulties related to the keyboard and the size of the screen.

**Perceived usefulness** was measured with four items mainly adopted from Venkatesh, Speir and Morris (2002). These items were complemented and modified for the purposes of the present study.
Perceived reliability included four items that were complemented and modified from the study of Lee et al. (2003), concentrating on privacy issues in sending and receiving personal information.

Intention had two items adapted from Venkatesh et al. (2002). The statements developed for the purposes of the study that capture perceived usefulness and reliability as well as intention are presented in Appendix.

Table 2 summarizes the measurement of the key concepts that was based on a latent factor structure. The measurement model was verified with confirmatory factor analysis and the reliabilities were assessed with composite reliability (CR) and level of average variance extracted (AVE), which both are based on factor loadings and error variances (see e.g. Fornell & Larcker, 1981, Diamantopoulos & Siguaw, 2000). The composite reliability coefficient should exceed .50, which roughly corresponds to a standardized loading of .70 (Hair, Anderson, Tatham, & Black 1998). If average variance extracted is less than .50 the variance due to the measurement error is larger than the variance captured by the construct (Fornell & Larcker, 1981).

<table>
<thead>
<tr>
<th>Concept</th>
<th>N of items</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional ability</td>
<td>5</td>
<td>.916</td>
<td>.652</td>
</tr>
<tr>
<td>Self-rated health</td>
<td>4</td>
<td>.853</td>
<td>.510</td>
</tr>
<tr>
<td>Cognitive ability</td>
<td>2</td>
<td>.866</td>
<td>.767</td>
</tr>
<tr>
<td>Technology anxiety</td>
<td>4</td>
<td>.850</td>
<td>.521</td>
</tr>
<tr>
<td>Physical restrictions</td>
<td>2</td>
<td>.902</td>
<td>.822</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>4</td>
<td>.905</td>
<td>.705</td>
</tr>
<tr>
<td>Perceived reliability</td>
<td>4</td>
<td>.890</td>
<td>.669</td>
</tr>
<tr>
<td>Adoption intention</td>
<td>2</td>
<td>.901</td>
<td>.822</td>
</tr>
</tbody>
</table>

All of the produced constructs had a high level of reliability as well as an excellent share of variance explained by the latent construct. The analysis represented next will summarize statistics represented by the mean values computed from the individual items.

4.3 Research procedure

The research process of this study consists of two parts. In the first part of the empirical study, we aim to segment the target population based on the self-rated health status, functioning and cognitive ability. The need based segments were formulated by clustering, applying the k-means clustering technique with IBM SPSS software. The second part of the empirical analysis consists of structural equation modelling for testing the proposed hypothesis using LISREL. For the the structural model, polychoric correlations with asymptotic covariances were used as input data due to the ordinal nature of the variables (Olsson, 1979; Rigdon, 1998). The estimation method
was unweighted least squares, which has no assumptions about the distribution of observed variables (Long, 1983). The modelling uses a multi-group analysis approach and applies the segmentation results as the basis for dividing the elderly into need based segments. Before testing the hypotheses, the measurement invariance was verified. This means that the confirmatory factor analysis was conducted simultaneously for both groups produced with the clustering (e.g. Byrne, 1998). The procedure included phases of 1) structural invariance (the composition of the measurement model is the same in both groups), 2) metric invariance (equal factor loadings in both groups) and 3) factor variance invariance (Steenkamp & Baumgartner, 1998; Atienza, Balaguer, & García-Merita, 2003; Byrne & Miller, 2009). The reliabilities were, in addition, evaluated across groups, which also supported the invariance of the measurement.

6 Results

6.1 User segments

The basic idea behind the segmentation was to distinguish two groups of senior citizens that differ in relation to functioning, cognition and perceived health, as the presumption is that smart home systems should be designed to match customer needs. Table 3 provides the cluster means and standard deviations as well as the statistical results for group wise differences. In case of all segmentation variables, the group wise difference is statistically significant at p<.001. The two groups that were obtained will subsequently be referred to as the “frail” and “well-coping” elderly. The group of frail elderly has lower functional abilities, lower perception of current health status and limitations in cognition.

Table 3. Descriptive information of clustering variables

<table>
<thead>
<tr>
<th>Segmentation variable</th>
<th>Frail elderly (N=184)</th>
<th>Well-coping elderly (N=322)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std.dev.</td>
</tr>
<tr>
<td>Functional ability*</td>
<td>2.35</td>
<td>.622</td>
</tr>
<tr>
<td>Self-rated health*</td>
<td>2.42</td>
<td>.701</td>
</tr>
<tr>
<td>Cognitive ability*</td>
<td>2.83</td>
<td>1.091</td>
</tr>
</tbody>
</table>

*mean difference significant at p<.001

The descriptive information of the group demographics is presented in Table 4. The frail elderly include somewhat older individuals. The age difference is statistically significant at p<.001. This is natural due to the aging process, but considering the standard deviation of age, both groups have quite a high variation in terms of age. The well-coping elderly include almost an even share of men and women, whereas the share of women rises with age (women living longer than men), which can be seen in the gender distribution of the frail elderly. This same trend can be seen when considering the marital status; the share of people living alone rises due to the increased share of widowed people.
Table 4. Segment demographics

<table>
<thead>
<tr>
<th></th>
<th>Frail elderly</th>
<th>Well-coping elderly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>66.80</td>
<td>64.46</td>
</tr>
<tr>
<td>Std.dev.</td>
<td>7.21</td>
<td>6.40</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>65.20%</td>
<td>51.50%</td>
</tr>
<tr>
<td>Female</td>
<td>34.80%</td>
<td>48.50%</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with a spouse</td>
<td>67.70%</td>
<td>73.10%</td>
</tr>
<tr>
<td>Single</td>
<td>7.00%</td>
<td>5.10%</td>
</tr>
<tr>
<td>Divorced</td>
<td>10.40%</td>
<td>10.30%</td>
</tr>
<tr>
<td>Widowed</td>
<td>14.90%</td>
<td>11.50%</td>
</tr>
</tbody>
</table>

The perception of technology was assessed between the segments (Table 5). Interestingly, the level of anxiety and perceived physical restrictions were the only source of difference between the groups. The frail elderly perceived the level of technology anxiety higher than the well-coping elderly. In addition, the perceived physical barriers related to using technology were clearly causing more problems for the frail elderly.

Table 5. Mean comparison of technology perceptions between the segments

<table>
<thead>
<tr>
<th>Technology perceptions</th>
<th>Frail elderly</th>
<th>Well-coping elderly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std.dev.</td>
</tr>
<tr>
<td>Technology anxiety*</td>
<td>1.96</td>
<td>0.994</td>
</tr>
<tr>
<td>Physical restrictions*</td>
<td>3.36</td>
<td>1.305</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>3.78</td>
<td>0.997</td>
</tr>
<tr>
<td>Perceived reliability</td>
<td>3.46</td>
<td>1.068</td>
</tr>
<tr>
<td>Adoption intention</td>
<td>3.61</td>
<td>1.137</td>
</tr>
</tbody>
</table>

*mean difference significant at p<.001

6.2 Structural model to explain

Before testing the hypothesis with a structural model, the measurement invariance was confirmed for the segments. Measurement invariance was achieved, indicating that the factor loadings, intercepts and residual variances across the groups were the same. Because the numbers of observation were somewhat inadequate for using the full latent factor structure in the path analysis, summated scales were applied by computing indicator error variances from the summated scale variance and composite reliability (see e.g. Fisher and Price, 1992; Childers, Carr, Peck and Carson, 2001). Table 6 summarizes the results of the modelling. The model itself produced an excellent fit to the data indicated by chi square, normed fit index (NFI) and non-normed fit index (NNFI) and root mean square error of approximation (RMSEA). Both NFI and NNFI should be higher than 0.9 and RMSEA lower than 0.05 indicates a very good fit (see e.g. Hayduk, 1989; Hair et al., 1998; Kelloway, 1998). For each path, the standardized path coefficient is reported, including its level of significance. The first part of the table (the
The unrestricted model) gathers the results of the basic model estimated separately for both groups. The second part of the table (the restricted model) includes the results of the comparison of the path coefficients across the groups.

The first hypothesis (H1) that intention is positively influenced by perceived service usefulness is supported by the results in both groups. A high and positive coefficient suggests that intention is strongly dependent on service usefulness. The same conclusion can be drawn for the second hypothesis (H2), as perceived service reliability also has a high and positive influence on intention. As for the current technology in terms of restriction and anxiety, the results are not congruent across the segments. Hypotheses H3 and H4 discussed the effect of technology anxiety on perceptions of new services. The only significant effect was found in the path from anxiety to reliability in the group of the frail elderly; thus the hypothesis H3 is restricted and H4 is partly supported by the data.

Table 6. Results of the modeling

<table>
<thead>
<tr>
<th>Hypoth.</th>
<th>Path</th>
<th>Frail</th>
<th>Well-coping</th>
<th>Hypoth.</th>
<th>dy² (ddf=1)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Service usefulness</td>
<td>Adoption intention</td>
<td>.682***</td>
<td>.828***</td>
<td>H8</td>
</tr>
<tr>
<td>H2</td>
<td>Service reliability</td>
<td>Adoption intention</td>
<td>.624***</td>
<td>.728***</td>
<td>H8</td>
</tr>
<tr>
<td>H3</td>
<td>Technology anxiety</td>
<td>Service usefulness</td>
<td>-.0790</td>
<td>-.066</td>
<td>H7</td>
</tr>
<tr>
<td>H4</td>
<td>Technology anxiety</td>
<td>Service reliability</td>
<td>-.145**</td>
<td>-.073</td>
<td>H7</td>
</tr>
<tr>
<td>H5</td>
<td>Physical restrictions</td>
<td>Service usefulness</td>
<td>-.153**</td>
<td>-.055</td>
<td>H7</td>
</tr>
<tr>
<td>H6</td>
<td>Physical restrictions</td>
<td>Service reliability</td>
<td>-.207***</td>
<td>-.120*</td>
<td>H7</td>
</tr>
</tbody>
</table>

Unrestricted model statistics: $\chi^2=8.07$ (p=.622), df=10, NFI=.990, NNFI=1.005, RMSEA=.010

*p<.050, **p<.010, ***p<.001

*d² is the change in model chi square when the degrees of freedom in the model has changed one unit (ddf=1)

Hypotheses H5 and H6 concentrated on the physical restrictions that occur when using ICT. Out of the two hypotheses, only H6 is completely supported, indicating that physical restrictions decrease the perceived reliability of new services. The decreasing effect of physical restrictions on service usefulness is significant only among the frail elderly; thus H5 is partly supported.

The next step in the analysis was to examine whether the path coefficients estimated in the unrestricted model were statistically the same across the groups (H7 and H8). In order to test the assumptions, each of the paths was in turn forced to be the same across the groups. This means that when estimating the model, the path from, for instance, usefulness to intention was not freely estimated for both groups. Instead, the path for the frail elderly was assumed to be the same as estimated for the group of the well-coping elderly. The change in the model chi square ($d^2\chi^2$ in Table 6) is used as an indicator of the model deterioration if the paths of the groups differ significantly from each other. Hypothesis H7 did not find any support when the paths of current technology anxiety and physical restrictions were fixed to be the same. However, a statistically significant decrease in model fit occurred when the paths from technology perceptions were
forced to be the same across groups. This indicates that the hypothesis H8 can be supported. Thus, the positive influence of service reliability and usefulness is stronger among well-coping senior citizens.

Table 7. Standardized indirect effects

<table>
<thead>
<tr>
<th>Indirect effects</th>
<th>Frail</th>
<th>Well-coping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology anxiety → Adoption intention</td>
<td>-0.159**</td>
<td>-0.074</td>
</tr>
<tr>
<td>Physical restrictions → Adoption intention</td>
<td>-0.258****</td>
<td>-0.122*</td>
</tr>
</tbody>
</table>

*p<.100, **p<.050, ***p<.001

In addition, to understand the complete effects of current technology attitudes, the indirect effects of physical restrictions and anxiety were estimated for the model. Table 7 includes the standardized estimates of the indirect effects of technology anxiety and physical restrictions on the adoption intention. The decreasing effect of technology anxiety on the willingness to use new services was significant only among the frail elderly. The indirect effect of physical restrictions was negative and significant in both groups.

7 Discussion

The purpose of this study was to analyze how different customers form their attitudes and adoption intention toward telecare services. As a result, the customer base in the research could be distinguished into categories: one that included well-coping senior citizens, and one consisting of frail senior citizens whose cognition and functioning related to daily activities are limited. When this information was attached to the model composed for explaining adoption intention of telecare services, the results suggested that differences exist between these two customer segments. The overall results indicate that attitudes related to the use of ICT influence perceptions of new services. Considering the results from a statistical point of view, these effects were the same across customer segments. However, the difference between the segments occurs with the perceived service characteristics and how they influence the adoption intention.

Taking a look at the results of the unrestricted model as a whole, it can be seen that the attitudes related to ICT have significant effects on the perceptions of new service among the frail elderly (although the difference between the groups is statistically insignificant). Technology anxiety causes insecurity only among the frail elderly and therefore indirectly inhibits the adoption of new services. Also physical restrictions related to ICT use have stronger negative effects on new service reliability and usefulness among frail elderly. Together, anxiety and restrictions are sources of uncertainty, and therefore also the potential benefits are more difficult to perceive. For the whole sample, our results indicate that greater physical restrictions significantly cause the new services to be perceived as less reliable, which is important due to the fact that telecare services are mainly targeted for the aging market. If services are designed to be interactive and require the customer to be an active participant in using them, the interface and device design should support easy access and unrestricted usage. As the level of adoption intention is the same for both groups, the perceived service characteristics have a smaller effect on the intention for
the frail group. This also supports the conclusion that current experiences with ICT might inhibit the adoption of new services.

Smart homes are not meant to include only ICT devices and systems, but they should be appropriately designed living environments particularly if the user has ADL limitations. People with impaired competencies are sensitive to the environment regarding their independence, which could be supported with appropriate manipulations (Wherton & Monk, 2008). For instance, the technologies may reduce limitations resulting from chronic diseases especially if the devices support the timing of daily activities (e.g. visual signs) in the case of memory disorders (Monk et al., 2006). In fact, perceptions of the functionality of the environment and self-confidence in new circumstances differ in cognitively impaired people compared to healthy subjects (van Hoof, Kort, Duijnstee, Rutten, & Hensen, 2010). This aspect of the system design process has not been taken into account in many smart home concepts which, instead, approach the smart home environment from the perspective of people without physical disabilities.

Recent studies on elderly care emphasize positive outcomes of the opportunity to continue living at home on an individual’s health because it supports being an active member of the community (Fänge & Ivanoff, 2009). Good health also has a positive influence on attitudes toward learning and adopting new routines into one's daily activities. In fact, healthy persons are more likely to adopt a technology based-service if the technologies increase their independence and delay the need for regular nursing. The key outcomes of this study are summarized in Table 8 and discussed in the following sections.

7.1 Theoretical implications

The present research contributes to the existing literature on innovation adoption and behavioral intention. The specified behavioral model was very appropriate for the aging market. In addition, the research extends information that previous research has introduced, as the focus of the research were the end-user consumers. The results also indicate that individuals belonging to the same market do not necessarily demonstrate the same type of adoption behavior when new services are introduced. This means that factors that either facilitate or inhibit innovative services are not the same across the market and their effect is not consistent. The market that consists of aging people has possibly several diverging segments in which the behavior has different features.

7.2 Practical implications

The technology anxiety of a person does not necessarily remain constant over time. Referring to research related to computer anxiety, it has been found to be a state anxiety that can be changed (Chua et al., 1999). This means that the level of anxiety can be altered by proper training targeted correctly for the individual’s level of knowledge and abilities. Privacy concerns regarding ICT
have been seen to increase resistance and anxiety to adopt new services if users do not understand how the services function or if security policies are inappropriately communicated. Therefore, education and training are important factors in increasing the utilization of ICT amongst elderly segments, influencing the efficiency of service from the perspective of users and service providers (Mitzner et al., 2010; Carpenter & Buday, 2007). The devices and services targeted to alleviate functional restrictions must be designed to be easy to learn and use in the given circumstances which set requirements particularly for user interfaces. The physical restriction might be impossible to overcome when the functioning and the level of cognition decreases. However, the interactive part of telecare must then include different types of services (monitoring, etc.). Finally, the familiarity of technology for the users is an important factor when one judges the reliability and usefulness of new services. That feature has a particular meaning amongst users with limited cognitive abilities, emphasizing the proactive role of telecare in health care rather than its preventive effects for acute care.

7.3 Research limitations and future research directions

As the study is cross-sectional, it is unable to clarify how sensitive the technology perceptions are to changes in health conditions or how they could have been changed. The usage of self-reported measures also composes a risk of common method bias, but on the other hand, several concepts used in this research are purely subjective and there would not have been any other way to conduct the measurement. In addition, the formation of the questions related to telecare services were based on quite a hypothetical situation, as no concrete telecare services were on the market at the time of the study. This might result in an excessively high level of adoption intention, as the respondents could not refer to previous experiences of related services. However, this provides interesting topics for future research. The new services that are about to be launched could be used as important cases that provide information related to the true perceptions of service usefulness and reliability, as well as how the presupposition related to the capabilities to use the new services has interfered with the adoption process. If possible, this type of study would be useful in a post-adoption situation, making it possible to analyze the true effect of perceptions on intention, as well as how the experiences have changed the attitudes. On the other hand, concerning service providers, research is also needed on how the differing end-user requirements are taken into account in the design process of service entities. The particular interest of this study is to explain the intention to adopt telecare services, but applying similar research settings to other care services can further provide valuable insights into service design in general.
### Table 8  Summary – Recognized limitations of the applicability of technology based services for the elderly

<table>
<thead>
<tr>
<th>Theoretical Contribution – Attributes influencing adoption of eHealth</th>
<th>Key empirical findings regarding particular user segments</th>
<th>Practical implications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Users</strong></td>
<td>Frailed elderly</td>
<td>Well-coping elderly</td>
</tr>
<tr>
<td>Functional and cognitive ability, and perceived health status differentiates user groups.</td>
<td>The segment represents the elderly with low self-rated health and decreased cognitive abilities. Functional ability tends to decrease in this group.</td>
<td>The segment represents the elderly with high self-rated health and good cognitive abilities. Significant changes from normal functional ability cannot be recognized.</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Physical restrictions negatively correlate with the perceived usefulness and reliability of new services. Technology anxiety diminishes the perceived reliability of technology based services.</td>
<td>The correlation between personal attitudes to technology and perceived usefulness and reliability were not found to exclude the negative influence of physical restrictions.</td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td>The perceived usefulness and reliability of technology based services increase the intention to adopt new services. However, the influence is weaker than amongst the well-coping elderly.</td>
<td>The perceived usefulness and reliability of technology based services increase the intention to adopt new services. The influence in this group was recognized to be statistically stronger than amongst the frail elderly.</td>
</tr>
<tr>
<td><strong>Indirect influences</strong></td>
<td>Physical restrictions were recognized to have a statistically significant negative indirect influence on the intention to adopt eHealth services amongst the well-coping elderly. Anxiety has a negative influence on the adoption intention, particularly in the segment of the frail elderly.</td>
<td>Alleviating the physical restrictions of individuals has positive effects on the intention to adopt telecare services. The familiarity of telecare amongst users with limited cognitive abilities is a remarkable factor in the acceptance of new services.</td>
</tr>
</tbody>
</table>

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**Notes:**
- Attributed findings are based on empirical research and user group characteristics.
- Practical implications highlight strategies for technology adoption and user segmentation.
Appendix: Measurement items

**Perceived reliability**
I believe that telecare services are reliable.
Information received through telecare services is as reliable as it would be on paper.
I see that transferring my personal information through telecare services would be as safe as during phone call contact.
I feel comfortable providing my personal information through telecare services.

**Perceived usefulness**
Telecare services would be useful in healthcare.
Telecare services would be an efficient way to communicate with health professionals.
Using telecare services might result clear benefits for following up my own health and treatment.
Benefits acquired with telecare services could ease up the work of health professionals.

**Intention**
Assuming I had access to telecare services, I intend to use them.
Given that I had access to telecare services, I predict that I would use them.

References


