The Adoption of Care Robots in Home Care – a survey on the attitudes of Finnish home care personnel

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Abstract

Aims and objectives: This article examines the attitudes of Finnish home care registered nurses, licenced vocational nurses, and other health and social care personnel towards the introduction and use of care robots in home care.

Background: The significance of care robotics has been highlighted in recent years. However, personnel-related social psychological barriers to the introduction of care robots have been given very little study.

Design: Cross sectional study conducted by questionnaire. The theoretical framework of the study is based on Ajzen's theory of planned behaviour and the research discussion about attitudes towards robots.

Methods: The research data was collected in five municipalities in different parts of Finland in 2016, and the questionnaire was answered by a total of 200 home care workers. The research data was analysed using exploratory factor analysis, Pearson product-moment correlation, one-way analysis of variance, and linear regression analysis.

Results: The results are consistent with Ajzen´s theory and previous studies on the acceptance of information systems in health care. Personnel behavioural intentions related to the introduction of robot applications in home care are influenced by their personal appreciation of the usefulness of robots, the expectations of their colleagues and supervisors, as well as by their own perceptions of their capacity to learn to use care robots. In particular, personnel emphasized the value of care robots in providing reminders and guidance, as well as promoting the safety of the elderly.

Conclusions: The study shows that an intimate human–robot relationship can pose a challenge from the perspective of the acceptance of care robots.

Relevance to clinical practice: From the perspective of the introduction of care robots in home care, personnel training and the construction of a positive working atmosphere play a key role. In addition, the introduction of robots requires further consideration of a number of ethical issues.

Keywords: home care, attitude, elderly, health care personnel, survey, care robot, home health nursing

What does this paper contribute to the wider global clinical community?

- There are potential psychological barriers that are important to take into account when planning the introduction of care robots in home care. In particular, an intimate human–robot relationship can pose a challenge from the perspective of acceptance of care robots.
- From the perspective of the adoption of care robots in home care, the most important social psychological factor is a person's estimate of how easy it will be to learn to use care robots.
- Home care personnel believe in the usefulness of robots in providing reminders, guidance and promoting the safety of the elderly, but they do not believe that a care robot can assist an elderly person in washing, getting dressed, toileting, or moving, for example, from a bed to a chair.

Introduction

The importance of health and welfare technology has increased in recent years. This is due not only to technological advances, but also to population aging and the problems of public finances which are being experienced in many Western countries, and the consequent need to increase the productivity of work in health and social care. The introduction of technology has been shown to improve patient safety, as well as the quality, accessibility and efficiency of care (e.g. Fetter 2009), although it has also attracted critical commentary (Black *et al.* 2011). The technology needed to help the elderly to cope at home has also developed to solve the challenges faced by an aging population. In the past few years, health and welfare technology has entered a new phase due to the development of robotics, and the preliminary experiences in robotics in geriatric healthcare have been positive (Agnihotri & Gaur 2016).

The introduction of care robots' changes nursing and care in many ways. This article is focused on the attitudes of Finnish home care registered nurses, licenced vocational nurses and other health and social care personnel towards the introduction and use of robots, and the adoption of care robots in home care. The determinants affecting the adoption of care robots can be analysed from the perspective of a wide variety of theoretical models (Alaiad & Zhou 2014). Previous studies (e.g. Chau & Hu 2001, Holden & Karch 2010, Rawstorne *et al*. 2000) have shown that the *technology acceptance model* (Davis *et al*. 1989) and the *theory of planned behaviour* (Ajzen 1991, 2001) are useful approaches for explaining the adoption of new technology in health care. Resultantly, the theoretical framework of this study is based on the theory of planned behaviour, and research discussions about attitudes towards robots (e.g. Bartneck *et al*. 2006, Broadbent *et al*. 2012, Nomura *et al*. 2006b, Syrdal *et al*. 2009).

Background

The theory of planned behaviour

In the theory of planned behaviour (Ajzen 1991), the concept of *behavioural intention* refers to a specific action intention – an intention to behave in a certain way or to perform a certain act. Looking at care robots, people's behaviour fundamentally depends on decisions of organisation. Rawstorne *et al*. (2000) argued that the theory of planned behaviour can also be applied to cases where the use of technology is mandatory. In the context of the technology acceptance discussion, behavioural intention means "an individual's motivation or willingness to exert effort to perform the target behavior" (Holden & Karsh 2010).

From the point of view of the introduction of new technology, employee *attitudes* play a key role. Attitude is multidimensional construct, which can be understood as a value judgment of a given target (Eagly & Chaiken 1993). In previous studies on attitudes towards robots, the target of the attitudes has varied. The attitude scale of Broadbent *et al.* (2012) is associated with the evaluation of various robot attributes. In turn, Nomura´s negative attitudes towards robots scale (NARS) is associated with attitudes towards the interaction with robots, attitudes towards the social influence of robots, and attitudes towards emotions in interactions with robots (Nomura *et al*. 2006b). In the experimental study of Nomura *et al*. (2006a), the negative attitudes towards robots explain the communicative behaviour in robot–human interaction. However, according to Ajzen (1991), specific attitudes explain and predict behaviour in specific situations much better than general attitudes.

According to Ajzen´s (1991) theory of planned behaviour, behavioural intentions are influenced not only by attitudes, but also by perceived behavioural control and subjective norms (cf. Figure 1). The concept of *perceived behavioural control* is based on Bandura´s (1982) concept of self-efficacy, and in this study it is concerned with how well people think they can cope with learning to use care robots. The concept of a *subjective norm* represents the belief of how closely people value the desirability of a particular behaviour (Ajzen 1991, 2001). In the context of health technology, the concept means the perception of the importance or relevance of others' beliefs about a person's use of a system, and thus it can refer, for example, to the opinions of doctors, colleagues, superiors, the senior management of a hospital, other important people, or subordinates. In terms of technology adoption, the results regarding the importance of subjective norms have been contradictory, but many studies have found a significant dependence between subjective norms and behavioural intention (Holden & Karsh 2010).

Figure 1 about here

Opportunities and challenges of care robotics

Robots have been developed with different functionalities, such as lifting robots, exoskeletons, assistive robots, companion robots, talking robots, emotional communication robots, and medicine dispensing robots. Robots can provide physical, social and medical assistance for the elderly (Bouwhuis 2016; cf. Table 1). Several earlier studies have shown that the most common problems threatening the independence of the elderly relate to mobility, self-care, domestic life and loneliness (Bedaf *et al.* 2013). Consistent with Bouwhuis's (2016) analysis of different types of care robots, the term *care robot* is also used in the broad sense in this study, referring to any robot that is used for a care task, especially as a support for the independent living of the elderly or to assist in home care.

Table 1 about here

According to previous studies, a care robot can provide effective assistance, particularly in emergencies. For example, in the case of a fall, the robot can communicate with an emergency centre or contact family caregivers (Broadbent *et al*. 2012, Federici *et al*. 2014). Health care personnel think it could be helpful if the care robot could remind residents of their ADLs (activities of daily living). However, in the study of Mast *et al*. (2012), elderly people rated emergency assistance as the most important task of care robots, and informal caregivers rated items related to reminding functions and emergencies most highly.

Alaiad and Zhou (2014) argued that health care robots could carry out various tasks, submit the results to a doctor, help in follow-up care with the family, remind the elderly to take medication and make sure that medications were used properly, communicate with the resident/doctor, and also help in physician therapy. Broadbent *et al*. (2015) mentioned that a care robot was particularly useful at blood pressure measurement, providing entertainment, and in making phone calls. In addition, Mordoch *et al*. (2013) said that social commitment robots are useful as a therapeutic intervention for elderly persons with dementia. Overall, a care robot should provide services which are personalized to the profile and evolution of the disease of each elderly person (Aloulou *et al*. 2013).

There are various development needs which need to be achieved, before robots are able to help the elderly with their daily activities (Vermeersch *et al*. 2015). According to previous research, health care personnel are sceptical towards care robots, and are concerned that a care robot will never be able to replace a human (Kristoffersson *et al*. 2011, Vermeersch *et al*. 2015). Health care personnel are also concerned about the safety and reliability of robots, and are doubtful about how a robot would be able to help the elderly in highly personal tasks (Broadbent *et al*. 2012). Furthermore, health care personnel also think that it would be problematic if there were barriers (such as closed doors) between the robot and the resident (Broadbent *et al*. 2012). In addition, the elderly are concerned about the robot breaking down (Vermeersch *et al*. 2015).

Hence, it is necessary to examine attitudes towards the use of care robots in particular tasks in home care, instead of just general attitudes towards robots (cf. Alaiad & Zhou 2014, Broadbent *et al.* 2012, Mast *et al.* 2012). Among these tasks, fall detection and the prevention of accidents are important in home care (Bedaf *et al*. 2013, Kristoffersson *et al*. 2011, Lattanzio *et al*. 2014), and the elderly themselves feel that care robots are most useful specifically for providing emergency assistance (Mast *et al*. 2016). Secondly, to promote independent living, the elderly need help with practical home care (Bedaf *et al*. 2013, Horihata *et al*. 2011, Schiomi *et al*. 2015). This may also involve elderly people

with cognitive impairment who need assistance in e.g. finding their belongings (Wu *et al*. 2016) and being reminded about things (Granata *et al*. 2013, Inoue *et al*. 2012). This study separately examines attitudes to robots that address the promotion of safety and practical home care, as well as the provision of guidance and reminders.

Aim

The aim of the study

This study examined the attitudes of Finnish home care registered nurses, licenced vocational nurses, and other health and social care personnel towards the introduction and use of robots, and the adoption of care robots in home care.

Research questions and hypothesis

The study asked: *How do personnel assess the usefulness of care robots for various tasks in home care? What social psychological factors explain personnel's intention to introduce care robots?* Based on the theory of planned behaviour (Ajzen 1991, 2001), the following hypothesis were tested: *Behavioural intention related to the introduction of care robots for home care depends on the perceived behavioural control of the care robot, using subjective norms related to care robots in the work community and attitudes towards care robots and their usefulness in home care.*

Methods

Design

Cross sectional study conducted by questionnaire. The theoretical framework of the study was based on Ajzen's theory of planned behaviour and, and thus the adoption of care robots was examined using the concepts of behavioural intention, attitudes, perceived behavioural control, and subjective norm.

Context

In Finland, the aim of Home Care Services is to support the elderly in coping at home for as long as possible, and to secure the elderly's safe, active living in the home environment. Home Care Services (domestic services and home nursing) organise nursing, care and necessary support services, in order to maintain the health and functionality of the elderly, and offer care in cases of illness or disorders.

Home nursing entails nursing and rehabilitation services. In Finland, Home Care Services and related support services for the elderly contain, for example, help with ADLs such as meals-on-wheels, eating, washing, dressing, getting out of bed or a chair, toileting, security phone service, and assistance with errands (Ministry of Social Affairs and Health 2017). The biggest domain in home care is to support the elderly with their daily living, routines and activities. In addition, it seems that the elderly need increasingly more help with medication because of their decreased cognitive abilities and many issues related to their health care such as multimorbidity and associated polypharmacy (Mannuccio & Nobili 2014). Furthermore, home care involves different nursing treatments like measuring blood pressure or blood glucose levels, evaluating the client's cognitive abilities, and wound care (Turjamaa *et al*. 2014).

In Finland, care robots have seen limited use in assisted living home environments, however, in institutional care and in private retirement homes there have been pilots of e.g. *Zora* robots, the therapeutic seal robot *Paro*, and the telepresence robot *Double*. To increase safety in housing, many kinds of advanced automation technologies are used, such as automatic medicine dispensers or smart fall detection systems. More recently, robotics for health care has been an important focus of development and innovation activities in Finland.

Sample

The survey sample consisted of all the employees of home care facilities in five municipalities in different parts of Finland. A total of 1100 registered nurses, licenced vocational nurses, and other health and social care personnel were approached, and the questionnaire was answered by a total of 200 home care workers. The sample was purposefully formed to be regionally comprehensive, with one selected municipality located in the Helsinki metropolitan area in Southern Finland, one in South Ostrobothnia in western Finland, and two in Northern Finland (Northern Ostrobothnia and Lapland). In addition, one federation of municipalities in South Eastern Finland was also selected for inclusion in the sample. The study involved one relatively large city (200 000 inhabitants, the fifth largest city in Finland), two medium-sized cities (50 000 - 100 000 inhabitants), as well as small rural communities. Altogether, the representativeness of the survey sample was quite good.

Instrument

The questionnaire contained a total of 83 questions, with 32 questions directly concerning care robots. These questions were formed as statements and comprised of Likert-type scale items (ranging from 1 = *totally disagree* to 5 = *totally agree*). This article focuses only on these questions.

Eleven questions were prepared related to three different attitudes towards care robots (cf. Table 5). The *robots as promoters of safety* attitude refers to the belief that it is possible to promote the safety of the elderly using care robots. It was studied by four statements relating to medication, health monitoring, and communication with relatives and healthcare personnel. In turn, the *robots as helpers in practical home care* attitude emphasizes the importance of robots in practical care and housework. Four issues relating to it focused on the use of robots in housework, assisting in the moving and washing of the elderly. The *robots as guides and prompters* attitude was examined using three questions related to the guidance of older people in physical exercises, using the phone or bank matters, as well as providing reminders. One statement was formed concerning the use of robots to reduce the anxiety and loneliness of an elderly person. The general fears surrounding care robots were studied using three Likert-scale attitude questions ("*I'm afraid that the introduction of care robots would make the treatment of elderly people inhumane/would add to the loneliness of elderly people/would endanger home care jobs*"). (Cf. Table 5.)

Alaiad and Zhou (2014) constructed a measure of the usage intention of health care robots, but there are no valid measures related to the introduction of care robots in home care. In this study, the measure for behavioural intention contained five questions related to a person's specific readiness, enthusiasm or motivation to introduce and use care robots. The questions concerned the introduction of technological applications and robots in general, and, questions related to the promotion of coping at home, safety, and the ADL's in-home care. The questions related to perceived behavioural control (six items) were connected to the respondents´ technological skills in general, their confidence in learning robot use, and their confidence in guiding others in robot use. The original measure for a subjective norm contained six issues relating to how co-workers value the introduction of care robots in home care. (Cf. Table 6.)

Furthermore, the respondent's age was also examined as according to a previous study, a person´s age has a negative association with technology usage, their attitudes towards technology usage and perceived ease of use (Porter & Donthus 2006), and is also a relevant factor from the perspective of attitudes towards robots (e.g. Bartneck *et al*. 2006, Scopelliti *et al*. 2005, Syrdal *et al*. 2013).

Procedure

The research data was collected in March-May 2016. In two municipalities the data was collected in paper form during staff development days of home care facilities, and all the participants present answered the questionnaire, however, a total of 81 employees did not participate in the development days due to vacation, sick leave and the necessary tasks of home care. In other municipalities an

electronic questionnaire was used, and was sent to all employees of the home care facility using their business email address.

Analysis

The data was analysed using IBM SPSS Statistics for Windows, version 23 (IBM corp., Armonk, N.Y., USA). Sum variables were formed as an average of individual questions. Before forming the sum variables of independent variables, the data was examined using exploratory factor analysis (Principal Axis Factoring, Varimax rotation with Kaiser Normalization). First, questions related to attitudes (eleven items) were analysed, followed by issues related to perceived behavioural control and subjective norm (twelve items). The number of factors was predetermined as three in the first analysis (reflecting three different attitudes) and two in the second analysis (subjective norm and perceived behavioural control). In the study, behavioural intention is seen as a dependent variable and the issues related to it (five items) were not analysed by factor analysis. The internal consistency of sum variables was estimated with Cronbach's alpha. Preliminary analyses were done using the original data, but for practicality, the missing values were replaced by a value of 3 (= *neither agree nor disagree*) when forming the sum variables.

The normality of distributions was checked using histograms and showed the distributions of sum variables as close to normal. Because a Likert scale is ordinal and distributions are not completely normal, the first dependencies were examined by non-parametric methods. There were only minor differences between the parametric correlations (using the Pearson product-moment correlation coefficient) and non-parametric correlations (using Spearman's rank correlation coefficient), thus, the dependencies were examined parametrically. A few researchers (e.g. Norman 2010) have suggested that parametric methods can also be utilized in the case of Likert scales. According to Clason and Dormody (1994), there are no hard and fast rules for sufficiently determining how normal is *normal* in the case of Likert scales, hence it is necessary to make these decisions using different criteria.

The actual statistical analyses were conducted using the Pearson product-moment correlation coefficient, partial correlation coefficient, independent samples t-tests, one-way analysis of variance, and linear regression analysis with the Enter method. The assessment of effect size of Pearson correlation coefficients is based on Cohen´s (1992) study, whereby the limits of small, medium and large effects are .1, .3 and .5 respectively. Before carrying out regression analyses, the validity of the conditions was checked. The normality of the residual distributions and the linearity condition were checked graphically, and the multicollinearity between the independent variables was examined using

the VIF coefficients. Before carrying out analysis of variance, the assumption of homogeneity of variance were checked by Levene´s test and the assumption of normality were checked by Kolmogorov-Smirnov test and Shapiro-Wilk test.

Ethical issues

The participants were informed about the voluntary nature of their contribution. The information letter explained that any information provided would be treated in confidence, and none of the participants would be individually identifiable in resulting publications. Information on how to contact the researchers was attached to the information letter so that participants could communicate with them if they had any questions or comments regarding the study. The respondents signed an informed consent form in one municipality, and in the other municipalities, answering the questionnaire was taken as informed consent. The results of the study have been presented in an objective, open and honest manner, and are to be used solely for research purposes (cf. The Finnish Advisory Board on Research Integrity 2012, WMA Declaration of Helsinki 2017). A statement on ethics for the performance and publication of the research obtained from the FUAS (Federation of Universities of Applied Sciences) Advisory Board on Ethics (1.6.2016).

Results

Respondents

In total, 200 Finnish home care workers answered the questionnaire. Of these, 59.5% were licensed vocational nurses, 22.5% were registered nurses, 8.0% were homemakers, and 10.0% were elderly care professionals, social workers, occupational therapists or other professionals. Most respondents (93.5%) were female, and the average age of the respondents was 43 years. Slightly more than half of the respondents (51.0%) were between 30 and 50 years of age, 15.2% were under 30 years old and one third (33.8%) were 50 years of age or older. The duration of work experience in home care varied from a few months to 39 years. Half of the respondents (52.5%) had worked in home care for at least ten years, and 19.5% for at least 20 years. However, a few of the respondents (8.5%) had a year or less of home care work experience.

The overall response rate was 18.2%. In municipalities (two municipalities, $N = 114$) where a paper form was used, response rate was 58.5%, and in municipalities where an electronic questionnaire

(three municipalities, N = 86) was used, response rate was 9.5%. The two groups did not differ significantly from each other in respect to behavioural intention (t = .805, p = .422). Municipalities did not differ each other in term of respondent´s ages or working experience. According to one-way analysis of variance there were also no significant differences in age (F(4,192)=1.478, p=.210) between the respondents from different municipalities.

Factor analyses and reliabilities

The final measures of independent variables were formed using exploratory factor analysis. The factor analysis related to attitudes explained 60.3% of the variance, and the factors´ eigenvalues were 2.50 (*robots as promoters of safety*), 2.29 (*robots as helpers in practical home care*) and 1.83 (*robots as guides and prompters*). (Cf. Table 2.)

Table 2 about here

The factor analysis related to subjective norm and perceived behavioural control explained 54.9% of variance, and the factors´ eigenvalues were 4.10 (*subjective norm*) and 2.49 (*perceived behavioural control*). Based on the factor analysis, two questions ("*I believe that employees in my working community would support each other in different technical and other questions relating to the use of robots if nursing robots were introduced in our unit*" and "*I believe that the introduction of nursing robots would be strongly resisted among the employees in our unit*") were excluded from the measure of subjective norm because their factor loadings were below .5, and thus the final measure for a subjective norm contained four issues. (Cf. Table 3.).

Table 3 about here

Missing values were minimal (a total of five pieces, i.e. 0.10% of the Likert scale questions that are included in the sum variables) and they were replaced by a value of 3 (= *neither agree nor disagree*) when forming the sum variables. The reliabilities of all measures were quite high (α>.8, cf. Table 4).

Table 4 about here

Personnel attitudes towards care robots

The respondents estimated that care robots would be particularly useful for reminding the elderly about taking medicine, week days, meetings, as well as guiding them in physical exercises (Table 5). Even 85.5% of the respondents totally or partially agreed with the statement "*A care robot can remind*

an elderly person to take their medicine, of the day of the week, of meetings". Similarly, most respondents (65.5%) at least partly agreed that a care robot can promote the safety of the elderly living at home. In contrast, only 15.0% of the respondents totally or partially agreed with the statement "*A care robot can help an elderly person with washing, dressing and using the toilet"*. Most respondents did not agree that a care robot could relieve the anxiety and loneliness of older people. Similarly, most of the respondents did not agree that care robots can assist an elderly person in household work or in moving, for example, from bed to chair.

Table 5 about here

The results show that there are certain fears related to the introduction of care robots. 30.0% of the respondents totally agreed with the statement "*I'm afraid that the introduction of care robots would make the treatment of elderly people inhumane*", and about 39.5% partially agreed. Some of the respondents were also afraid that the introduction of care robots would add to the loneliness of elderly people and endanger home care jobs (cf. Table 5).

Perceived behavioural control and subjective norm

Perceived behavioural control was examined using six questions (cf. Table 6). Half of respondents (50.0%) believed they are technologically competent, with 24.5% totally or partially disagreeing with this perception. However, 76.5% of respondents were confident in their ability to learn how to use care robots, if they were to become part of their unit. 71.0% of respondents totally or partially agreed that they were confident in their ability to learn simple programming for care robots if they were provided with the necessary training, and a further 59.5% were confident in their ability to learn how to use care robots to guide others in doing so. 40.0% of the respondents totally or partially agreed with the statement "*I believe that teaching elderly people how to use care robots would not be difficult for me*".

Table 6 about here

According to the respondents' assessments, their working community´s attitude towards the introduction of care robots is not particularly positive, although not negative (cf. Table 6). For example, while 11.1% of the respondents totally or partially agreed with the statement of "*My working community views the introduction of care robots for home care in a positive light*", 37.7% totally or

partially disagreed with it. More than half of the respondents (51.3%) took a neutral position to the statement.

Behavioural intention and factors that affect it

Overall, the respondents estimated that they are quite ready to introduce care robots if the matter became topical in their organization. Of the respondents, 71.5% totally or partially agreed with the statement "*Generally, I'm ready to implement new technological applications if they can enhance the quality of work of home care and I'm even enthusiastic about it"*. Of the respondents, 68.5% totally or partially agreed that they would be ready to experiment with and introduce new robot technology in home care, if it could help elderly people to cope independently at home. Also, a large proportion of the respondents were ready to introduce care robots that enhance the safety of medication (65.8%) and the safety of elderly people who live at home (62.5%). However, only 38.5% of respondents totally or partially agreed that they would be very motivated to introduce robotic technology that eases everyday tasks in home services and to instruct customers as required. (cf. Table 6.)

The analysis of correlations (cf. Table 7) shows that a person's intention to introduce care robots depends strongly upon the person's attitude towards robots, a sense of control regarding the use of robots, and also the normative expectations. All of these correlation coefficients are more than 0.5, that is to say the effect size is large, with the exception of the correlation between behavioural intention and attitudes related to robots as helpers in practical home care. Furthermore, it should be noted that different attitudes also have strong correlations with each other. For example, the correlation between *robots as promoters of safety* and *robots as guides and prompters* is r=.671 (p<.001).

Table 7 about here

As the Table 7 shows, age does not correlate with the behavioural intention, although the correlation between age and the perceived behavioural control is significant ($p < .001$) but small.

A linear regression analysis was employed to examine the factors that explain behavioural intention. The first regression model (shown in Table 8) includes all of the independent variables which were examined, and in the second model, the non-affected variables ($p > .05$) have been removed. Both models explain behavioural intention well ($R^2 > .7$).

The analysis shows that the perceived behavioural control explains behavioural intention most strongly, and this is also consistent with the examination of correlates. As expected, the effect of subjective norms is significant in both statistical models. The most relevant variable related to

attitudes towards robots seems to be a belief that care robots are useful in promoting the safety of the elderly. In addition, a belief that robots can be useful in providing guidance and reminders would seem to be positively associated with behavioural intention.

Table 8 about here

According to the regression analysis, there is a weak positive dependence between age and the behavioural intention, that is, older respondents are more willing to introduce care robots than younger ones. It seems that the effect of age is dualist, in that age has a negative correlation with the perceived control of care robots, which in turn is strongly correlated with behavioural intention, but on the other hand the direct effect of age is positive when the effect on perceived behavioural control is removed (the partial correlation between age and behavioural intention is r =.226 when perceived control is viewed as a controlling variable, p=.001).

Discussion

Social psychological determinants that affect the adoption of robot technology have not previously been studied in the context of home care, but the results of the study are consistent with the theory of planned behaviour (Ajzen 1991), and with previous studies about the acceptance of information systems in health care (Holden & Karsh 2010). Thus, the hypothesis that '*Behavioural intention related to the introduction of care robots for home care depends on the perceived behavioural control of the care robot, using subjective norms related to care robots in the work community and attitudes towards care robots and their usefulness in home care.*' is supported. The motivation or willingness to introduce care robots depends most strongly on a person's estimation of how easy it will be to learn to use care robots (i.e. perceived behavioural control). Other significant factors are the person's assessment of how useful the care robot will be (e.g. attitudes related to the safety of the elderly, reminding the elderly, and guiding physical exercises), as well as the perceived evaluations and expectations of the workplace community (i.e. the subjective norm).

Perceived behavioural control is a key factor in terms of the adoption of care robots, and it is therefore necessary to emphasize the importance of training that focuses on a wide variety of technical skills. Because of a difference between the specific perceived behavioural control related to the use of robots and a general or technology-specific self-efficacy (cf. Turja *et al.* 2017), in addition to normal health and communication technologies, education should also include the programming of care robots, as well as their use. Ajzen´s (1991) concept of perceived behavioural control applies not only to a

person´s actual technological skills, but also to their perceived control of technology. Thus, it is not sufficient to only teach technological skills, but also to create a positive experience so that a person is able to use the technology more confidently. Robotic technology is developing rapidly, and it is therefore particularly important that home care personnel learn to rely on their own capacity to learn about new technologies.

Based on previous studies (Chau & Hu 2001, Davis *et al.* 1989), it is not a surprise that the effect of the subjective norm is weaker than the effects of perceived behavioural control and attitudes towards robots. However, it is significant, and so in terms of the introduction of care robots in home care, the construction of a positive working atmosphere also plays a key role.

As part of this process, it is also necessary to discuss the fears surrounding robots. As an example, the fear that the introduction of care robots would endanger home care jobs is completely unfounded when we consider the rapid aging of the population. However, it is evident that the introduction of robots will influence the roles and responsibilities of home care personnel. According to the findings, a person´s age presents no barrier to the introduction of robot technology. However, the study found a negative correlation between age and perceived behavioural control. Thus, it is essential that especially older home care workers receive adequate training before any new technology is introduced.

According to the results, home care personnel welcomed the use of robots for their capacity to remind elderly people about certain things, for increasing safety, or for guiding physical exercises, and this is consistent with previous studies (e.g. Mast *et al*. 2012). Medicine dispensing robots, advanced security technology and use of Zora robots for guiding are examples of current robot technologies. However, it should be emphasized that the estimated usefulness of care robots depends not only on the benefits of care robots, but also on the respondent´s experiences and abilities with current robots.

The results show that home care personnel do not believe in the usefulness of care robots in providing physical care, or in relieving anxiety or loneliness. Also, consistent with the previous findings of Huryk (2010), a large proportion of home care personnel fear that the introduction of care robots would dehumanize the treatment of the elderly. So, despite being situated in the context of home care, the study is in line with previous studies (Kristoffersson *et al*. 2011, Vermeersch *et al*. 2015) where health care personnel believe that a care robot will never replace a human, and with the study of Broadbent *et al*. (2012) where health care personnel are doubtful about how a robot would be able to help the elderly in highly personal tasks. The results are especially interesting from the perspective of the development of lifting robots. Lifting robots – such as the *RIBA* robot that assists with patient

transfer from e.g. bed to wheelchair and back, using human-type arms (Mukai *et al*. 2010) – raise the question of the relationship between intimacy and autonomy. For some older people, this kind of robot could substantially increase a person's autonomy. However, home care personnel still held distinct reservations.

An examination of attitudes to robots also raises some technological challenges in the introduction of care robots. The current abilities of care robots are still limited (Bouwhuis 2016), and there are various development needs that need to be addressed before robots are able to help the elderly with their daily activities (Vermeersch *et al*. 2015). Home care work includes a wide variety of tasks, and each person´s situation and needs are different, as are the individual homes in which they live. For example, it is seen as too difficult for current care robots to assist with toileting in real homes. Similarly, many simple domestic tasks can be very difficult for robots to accomplish. Thus, the benefits of robots are quite limited in terms of home care, if helping in daily activities still requires home care personnel to visit many times a day. It is therefore important to ask what kind of robots are needed in home health care and the promotion of the independent living of the elderly, and what tasks they will need to perform. Bedaf *et al*. (2013) argued that the introduction of robots is not justified when tasks can be solved just as effectively by simpler and cheaper technology. The selection of the optimal technology requires a careful consideration of technology, economics and the practical details of home care work.

Methodological strengths and limitations

The content validity of the survey was established by basing the statements contained within it on previous research on the topic. The questionnaire was pre-tested among nursing students (N = 15), and some minor changes related to layout and wording were made. The reliabilities of all the measures were quite high (Cronbach's alpha over 0.8).

The research data was collected in five municipalities in different parts of Finland. The response rate was quite low (18.2%), and it could be assumed that those who responded were probably more in favour of care robots than non-respondents. However, no differences appear between the two municipalities with high response rates (58.5%) and three municipalities with low response rates (9.5%) when comparing behavioral intention. Moreover, there are no significant differences in age between the respondents from different municipalities.

The sample was intentionally formed to be regionally comprehensive. Despite the low response, the representativeness of the survey can be seen to be quite good. The gender distribution of respondents was close to the corresponding national proportion (93.5% in the sample compared to 94.3% reported

by *Super***,** which is a large health care sector labour union in Finland: Super 2017), and the average age of the respondents was close to the national average (43.2 years old in the sample compared to 43 years old reported by *Super*: Super 2017). However, it is acknowledged that the sample is not fully representative as south-west Finland and central Finland are missing from the research data**.**

The analysis was only based on Finnish data and therefore the results cannot be generalized directly to other countries. Much more research and cultural analysis is required to demonstrate the relationship between social psychological factors and the introduction of care robots. Previous studies have suggested that the robot-attitude scale (NARS) may be susceptible to cultural differences (Syrdal *et al*. 2009) and cultural differences have been shown in attitudes towards robots between, for example, Japanese and Western people (Syrdal *et al*. 2013).

Of course, the responses to the attitude questions reflect respondents´ individual experiences and perspectives. In Finland, care robots have been used especially for guidance, but not for example in lifting. Thus, it is logical that these respondents perceived that care robots are useful in guiding, but not necessarily lifting. It can therefore be assumed that the results would have been different if the study had been conducted for example, in Japan, where people have more experience with lifting robots such as *RIBA*. In contrast however, there is no reason to suppose that the analysis of factors influencing the behavioural intention would be dependent on culture in the same manner.

Finally, it should be noted that, within the context of the introduction of care robots, the importance of social psychological factors is limited. Several technological, economic and political factors also come into play in such a discussion, but regardless of these, this study highlights some of the potential social psychological barriers that are important to consider when planning the introduction of care robots in home care.

Conclusions

The study shows that an intimate human–robot relationship can be a challenge from the perspective of the acceptance of care robots, and home care personnel do not believe in the usefulness of care robots in physical care, or in relieving anxiety or loneliness. By contrast, home care personnel welcomed the use of robots for their capacity to remind elderly people about things, for increasing safety, or for guiding physical exercises. The introduction of robots for providing reminders, guidance and promoting safety is relatively unproblematic because these tasks are simple enough for current care robots to undertake, and they do not require too close a human–robot relationship. On the other

hand, questions arise as to what kind of technology is needed and how advanced it needs to be in order to e.g. provide reminders or raise an alert in the case of a fall.

Relevance to clinical practice

Based on the results of this study, it is possible to offer some conclusions regarding robot-related training for health care and home care. Future training will need to focus on a wide variety of technical skills such as the programming of care robots, as well as their use. It is particularly important that home care personnel learn to rely on their own capacity to learn about new technologies. From the perspective of the introduction of care robots in home care, also the construction of a positive working atmosphere play a key role.

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Tables and figures

Table 1: Various types of care robots and examples of them (source: Bouwhuis 2016, 206).

		Area of assistance		
		Physical	Social	Medical
Robot type	Lifting	Ri-Man (and RIBA)	-	-
	Exoskeletons	Mindwalker	-	-
	Assistive	(NAO)	NAO	(NAO)
	Companion	-	Pepper	-
	Talking	-	Zora	(Zora)
	Emotional	-	Paro	-
	Service	Roomba	-	-

Table 2: Home care personnel's' attitudes towards care robots, factor loadings (N=197).[1]

Question[2] A care robot can…	Factor 1	Factor 2	Factor 3
Robots as promoters of safety			
help an older person communicate with relatives and friends	.577		
help observing an older person's state of health (i.e. remote communication with doctor or nurse, real-time conveying of health information)	.770		
help with medication (e.g. giving medicine, recognising medicine, observing medicine use)	.672		
contribute to the safety of an older person living at home (e.g. by informing relatives and/or health care workers of sudden change in the state of health)	.767		
Robots as helpers in practical home care			
help an older person with washing, dressing up and using the toilet		.661	
help an older person move (e.g. moving from bed to chair)		.706	
assist an older person in light household work (e.g. cooking, making their bed, doing the dishes, using the dishwasher)		.653	
assist an older person in heavy household work (cleaning the windows, lifting)		.654	
Robots as guides and prompters			
remind an older person to take their medicine, of week days, of meetings			.622
guide an older person with the use of phone or bank-related issues			.596
guide an older person in physical exercise			.658

[1] Principal Axis Factoring method, Varimax rotation with Kaiser Normalization. Loadings below 0.5 not shown. Factor analysis explains 60.3% of variance.

[2] The original language of the questionnaire was Finnish – the items have been translated by an official translator.

Table 3. Questions related to perceived behavioural control and subjective norm, factor loadings. (N=199).[1]

Question[2]	Factor 1	Factor 2
Perceived behavioural control		
Generally speaking, I consider myself technologically competent.	.589	
I'm confident in my ability to learn how to use care robots, if they were to become part of my unit.	.807	.
I believe that it would be easy for me to learn how to use the care robots that may be used in home care in the future.	.803	
I'm confident in my ability to learn simple programming of care robots if I were provided the necessary training.	.851	
I'm confident in my ability to learn how to use care robots to guide others to do the same.	.860	
I believe that teaching elderly people how to use care robots would not be difficult for me.	.648	.
Subjective norm		
Generally, I'm ready to and even enthusiastic about implementing new technological applications if they can enhance the quality of work of home care.		.601
My working community views the introduction of care robots for home care in a positive light.		.820
My co-workers are enthusiastic about the possible use of care robots in home care.		.796
I believe that my working community would support the use of care robots in home care.		.733
I believe that employees in my working community would support each other in different technical and other questions relating to the use of robots if care robots were introduced in our unit.[3]		
I believe that the introduction of care robots would be strongly resisted among the employees in our unit.[3]		

[1] Principal Axis Factoring method, Varimax rotation with Kaiser Normalization. Loadings below 0.5 not shown. Factor analysis explains 54.9% of variance

[2] The original language of the questionnaire was Finnish – the items have been translated by an official translator.

[3] Statement do not include in final measure of subjective norm

Table 4: Sum variables and their reliabilities.

Variable	**N**	**mean**	**SD**	**Items**	**Alpha**
Dependent variable:					
Behavioural intention	199	3.56	0.91	5	.875
Independent variables:					
Perceived behavioural control	200	3.54	0.92	6	.901
Subjective norm	199	2.67	0.79	4	.855
Robots as promoters of safety	199	3.38	1.09	4	.865
Robots as helpers in practical home care	199	2.58	1.05	4	.824
Robots as guides and prompters	199	3.78	0.97	3	.817

Table 5: Home care personnel's attitudes towards care robots, distributions of responses.

Question	*N*	1 Totally dis-agree (%)	2 Partial-ly dis-agree (%)	3 Neither agree nor disagree (%)	4 Partial-ly agree (%)	5 Totally agree (%)	Total (%)
Robots as promoters of safety A care robot can …							
help an elderly person communicate with relatives and friends	199	14.6	13.0	13.6	40.7	18.1	100.0
help observing an elderly person's state of health (i.e. remote communication with a doctor or nurse; the real-time conveying of health information)	200	15.5	16.5	18.5	33.0	16.5	100.0
help with medication (e.g. giving medicine, recognising medicine, observing medicine use)	200	13.5	12.5	16.0	41.0	17.0	100.0
contribute to the safety of an elderly person living at home (e.g. by informing relatives and/or health care workers of sudden change in the state of health)	200	10.0	9.5	15.0	38.0	27.5	100.0
Robots as helpers in practical home care A care robot can …							
help an elderly person with washing, dressing up and using the toilet	200	45.0	25.5	14.5	13.5	1.5	100.0
help an elderly person move (e.g. moving from a bed to a chair)	200	26.0	19.0	16.0	29.5	9.5	100.0
assist an elderly person in light household work (e.g. cooking, making their bed, doing the dishes, using the dishwasher)	199	22.6	23.6	20.1	26.7	7.0	100.0
assist an elderly person in heavy household work (cleaning the windows, lifting)	200	28.5	14.5	17.0	28.5	11.5	100.0
Robots as guides and prompters A care robot can …							
remind an elderly person to take their medicine, of the day of the week, of meetings	200	3.5	4.5	6.5	39.5	46.0	100.0
guide an elderly person with the use of a phone or bank-related issues	199	15.1	12.0	17.1	37.7	18.1	100.0
guide an elderly person in physical exercise	200	5.5	8.5	10.0	50.5	25.5	100.0
Other attitude issues							
A care robot can ease the anxiety and loneliness of an elderly person.	198	30.3	21.7	14.6	25.3	8.1	100.0
I'm afraid that the introduction of care robots would make the treatment of elderly people inhumane.	200	4.5	10.5	15.5	39.5	30.0	100.0
I'm afraid that the introduction of care robots would add to the loneliness of elderly people.	198	6.0	16.7	19.7	30.3	27.3	100.0
I'm afraid that the introduction of care robots would endanger home care jobs.	200	19.5	18.0	27.0	17.5	18.0	100.0

Table 6: Behavioural intention, perceived behavioural control and subjective norm, distributions of responses.

Question[1]	*N*	1 Totally disagree (%)	2 Partially disagree (%)	3 Neither agree nor disagree (%)	4 Partially agree (%)	5 Totally agree (%)	Total (%)
Behavioural intention							
Generally, I'm ready to and even enthusiastic about implementing new technological applications if they can enhance the quality of work of home care.	200	6.0	10.5	12.0	47.5	24.0	100.0
I would be ready for experimenting and introducing new robotic technology in home care if it could ease elderly people's independent coping at home.	200	6.5	6.5	18.5	45.0	23.5	100.0
I would be ready for the introduction of care robots that ensure the safety of elderly people who live at home.	200	6.5	14.0	17.0	40.5	22.0	100.0
I would be enthusiastic about introducing robotic technology that enhances the safety of medication in home care.	199	6.0	8.1	20.1	43.2	22.6	100.0
I would be very motivated to introducing robotic technology that eases everyday tasks in home care and to the instruction of customers it requires.	200	11.0	16.5	34.0	29.5	9.0	100.0
Perceived behavioural control							
Generally speaking, I consider myself technologically competent.	200	8.5	16.0	25.5	38.5	11.5	100.0
I'm confident in my ability to learn how to use care robots, if they were to become part of my unit.	200	4.0	3.0	16.5	39.5	37.0	100.0
I believe that it would be easy for me to learn how to use the care robots that may be used in home care in the future.	200	6.5	10.0	23.5	40.5	19.5	100.0
I'm confident in my ability to learn simple programming of care robots if I were provided the necessary training.	200	6.0	7.0	16.0	40.5	30.5	100.0
I'm confident in my ability to learn how to use care robots to guide others to do the same.	200	9.5	11.0	20.0	40.5	19.0	100.0
I believe that teaching elderly people how to use care robots would not be difficult for me.	200	12.5	21.0	26.5	30.0	10.0	100.0
Subjective norm							

Generally, my working community views introducing new technology for home care in a positive light.	200	10.5	28.0	36.0	22.5	3.0	100.0
My working community views the introduction of care robots for home care in a positive light.	199	14.6	23.1	51.3	9.5	1.5	100.0
My co-workers are enthusiastic about the possible use of care robots in home care.	200	16.0	25.5	49.5	8.5	0.50	100.0
I believe that my working community would support the use of care robots in home care.	200	13.0	22.0	44.0	18.0	3.0	100.0
I believe that employees in my working community would support each other in different technical and other questions relating to the use of robots if nursing robots were introduced in our unit.[1]	200	4.4	8.0	20.5	45.5	22.0	100.0
I believe that the introduction of care robots would be strongly resisted among the employees in our unit.[1]	200	6.5	13.5	37.5	27.5	15.0	100.0

[1] Statement do not include in final measure of subjective norm.

Table 7: Pearson correlation between variables.

Variable	**Behavioural intention**	**Perceived behavioural control**	**Subjective norm**	**Robots as promoters of safety**	**Robots as helpers in practical home care**	**Robots as guides and prompters**
Behavioural intention	1					
Perceived behavioural control	.759 *p*<.001 *N*=200	1				
Subjective norm	.567 *p* <.001 *N*=200	.444 *p* <.001 *N*=200	1			
Robots as promoters of safety	.648 *p*<.001 *N*=200	.533 *p*<.001 *N*=200	.414 *p*<.001 *N*=200	1		
Robots as helpers in practical home care	.484 *p*<.001 *N*=200	.376 *p*<.001 *N*=200	.338 *p*<.001 *N*=200	.531 *p* <.001 *N*=200	1	
Robots as guides and prompters	.619 *p*<.001 *N*=200	.505 *p*<.001 *N*=200	.415 *p*<.001 *N*=200	.671 *p*<.001 *N*=200	.617 *p*<.001 *N*=200	1
Age	-.064 *p*=.370 *N*=198	-.271 *p*<.001 *N*=198	.137 *p*=.054 *N*=198	-.093 *p*=.193 *N*=198	-.061 *p*=.393 *N*=198	-.080 *p*=.261 *N*=198

Table 8: Regression analyses (dependent variable: behavioural intention). (N = 198.)

	Model 1 (all independent variables)				Model 2 (non-affected variables have been removed)			
Independent variable	*B*	*SE B*	*β*	*p*	*B*	*SE B*	*β*	*p*
(constant)	-.203	.232	-	.384	-.210	.233	-	.368
Perceived behavioural control	.511	.051	.515	<.001	.512	.051	.516	<.001
Subjective norm	.203	.054	.175	<.001	.207	.054	.178	<.001
Robots as promoters of safety	.163	.047	.194	.001	.171	.046	.204	<.001
Robots as helpers in practical home care	.048	.044	.055	.274	-	-	-	-
Robots as guides and prompters	.122	.055	.129	.029	.146	.051	.155	.005
Age	.006	.003	.083	.048	.006	.003	.083	.050
R^2 / adjusted R^2	.717 / .708				.715 / .708			
F	80.6 (*p*<.001)				96.4 (*p*<.001)			

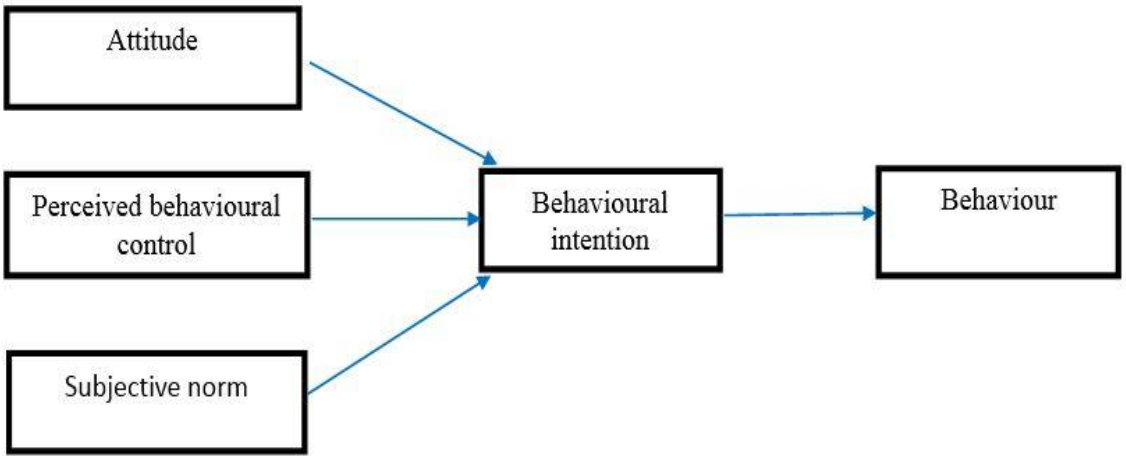

Figure 1: The theory of planned behaviour (Ajzen 1991, 2001)