

**The role of acceptance and perceived usefulness of unobtrusive monitoring technology
for dementia home care**

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Abstract

Background: The population is ageing, while health-related problems are considered a frequent problem in older age. Dementia is prevalent among elderlies and progresses in stages with continuing cognitive decline. Informal care provided at home by relatives or acquaintances is favourable for the patient's quality of life and extended independent living. On the other hand, negative consequences for informal caregivers are related to physical and mental health, finances, and social life, while caring for someone with dementia is especially hard due to the nature of the syndrome. eHealth seems to be a valuable tool to support dementia home care. Radio-frequency-based monitoring systems are unobtrusive technologies that might capture emergencies, patterns, and vital signs to relieve informal caregivers. To enable using a human-centred and holistic design approach, the attitudes and opinions of users are important to investigate. The role of acceptance and perceived usefulness of technology was shown to be relevant for successful implementation and adoption, which constitutes the foundation of the current study. Thus, the perception of acceptability and usefulness of the radio-frequency-based monitoring systems among informal caregivers of people with dementia will be central aspects of this research.

Methods: A quantitative-based cross-sectional study was conducted with 79 informal caregivers from Germany and the Netherlands, who were primarily contacted via Alzheimer's associations and informal caregiver networks. Scenarios focused on different monitoring goals that are central in dementia care were constructed to assess different aspects of each presented situation. The scenarios covered the following care situations: acute safety-related situations, safety-related risk predictions, self-care behaviour, nocturnal wellbeing, and monitoring of long-term patterns. Respondents were presented with questions concerning acceptability and perceived usefulness of the monitoring system for each scenario using a 5-point-Likert scale. Next to descriptive statistics, the Friedman test, the Wilcoxon signed-rank test, and Spearman's rank-order correlation were employed to investigate differences between scenarios and the association between the two concepts of acceptance and perceived usefulness.

Results: The mean (sd) age of the 79 respondents was 53.6 (12.1), with 75% of them being female. The majority care for one of their parents and commonly one other informal caregiver was involved. The mean (sd) age of the care recipients was 81.2 (9.1), with the majority living together with at least one other person. Acceptance was seen to be slightly positive for acute safety-related situations and nocturnal wellbeing, with a median of 3.5. All five scenarios

were perceived as moderately useful, with the median ranging from 3.6 to 3.9. Significant differences were found regarding acceptance ratings between multiple scenarios ($p < .001$), whereas the added value of the acute safety-related situations in relation to perceived usefulness was visible. Lastly, the association between acceptance and perceived usefulness of the technology was found to be moderate to strong.

Conclusion: Generally, slightly positive acceptance and perceived usefulness ratings of the monitoring technology for dementia care were observed in this study. Monitoring acute safety-related situations was shown to be especially useful. Further research should concentrate on possibilities to enhance ratings of acceptance and perceived usefulness, thereby increasing the chances of widespread adoption. Moreover, the observed association between acceptance and perceived usefulness should also be taken into account. Enrichments of the findings of this study by using qualitative research will be necessary to arrive at a thorough understanding of the determinants of acceptance of the technology in order to rethink the monitoring system.

Introduction

The population is ageing, primarily due to increased life expectancy and a downward trend in fertility rates that have been observed worldwide since the 1970s (Vollset et al., 2020). While in 2015, the age group > 60 years accounted for 12% of individuals worldwide, it is expected to make up 22% of the whole population by 2050. Despite the advances in medicine and gerontology, the process of ageing cannot be stopped. Hence, the high prevalence of health problems in elderlies increasingly challenges the healthcare system and informal caregivers. Overall, the demand for medical help and assistance can be expected to rise incrementally due to the increasing ratio of elderly in the population (World Health Organization, 2021).

Dementia is among the leading causes of dependence and disability in elderlies and affects about 55 million individuals worldwide, with an annual incidence of around 10 million (World Health Organisation 2015; World Health Organization, 2021a). Several types of dementia can be distinguished, with Alzheimer's disease being most prevalent, accounting for 65% of dementia cases (Radtke, 2022). The syndrome progresses in stages and different scales were designed to determine the degree of cognitive decline (CD) of persons with dementia (PwD). For example, the Reisberg Scale distinguishes seven stages, of which the first three stages are not yet considered to be a form of dementia (Reisberg et al., 1982). Stage four is classified as early dementia with symptoms being mostly cognitive or social in nature, e.g., impaired concentration and short-term memory, difficulties with aspects of daily living like household chores, and limited social interaction. Stages five and six represent mid-stage dementia with moderately severe to severe CD. The need for support and assistance is commonly prevalent due to progressing cognitive decline and an impaired sense of orientation. Another issue is wandering and getting lost, which might lead to decreased safety and increased caregiver burden (Hope et al., 2001). Typical for stage six dementia is complete dependence on assistance in activities of daily living (ADLs) and inability to remember significant names or events. Physical symptoms like impaired control of bodily functions (e.g., incontinence) and speech, behavioural and character changes, and constrained movement are commonly observed as well. Next to that, anxiety and withdrawal are often experienced by PwD with mid-stage dementia. In the last stage called late dementia, PwD have lost most of their abilities like walking, moving, and communicating, thus, they are fully dependent on assistance and care (DementiaCareCentral.com, 2020).

Dementia is still incurable, which is why treatment and care are central. Residential care is one option, whereby formal caregivers provide treatment and support PwD in activities of daily living (ADL), e.g., in a nursing home setting or in memory care units that are specifically designed for people suffering from dementia (Alzheimer's Association, 2020). However, informal care is considered the preferred mode of care and is particularly governmentally advocated in Germany and the Netherlands (Eurocarers, 2021; Eurocarers, 2021a). The primary reason for that is the aim of extended independent living, which means that PwD can stay in their home environment as long as possible while being supported by daily life (OECD, 2015). Informal caregivers are mostly family and friends who care for their loved ones without officially being paid for it (Johns Hopkins Medicine, n.d.).

Despite the value of independent living and receiving informal care for PwD, informal caregiving is associated with a multitude of challenges on part of the informal care providers. The burden that informal caregivers experience as a consequence of caring for their loved ones is two-fold, i.e., subjective and objective (Montgomery et al., 1985). Subjective burden relates to informal caregivers' wellbeing, including emotional, physical, and social aspects. Constant concern, fears about the future and struggling to accept the diagnosis is common among informal caregivers of persons with dementia. The evidence for the negative impact of informal caregiving on emotional wellbeing, especially in terms of anxiety-related and depressive symptoms, is unambiguous and consistent (Lindeza et al., 2020; Schulz et al., 1995; Stratmann et al., 2021). Despite emotional and physical issues, many informal caregivers claim that residential care is not an option even though their loved one needs continuous supervision (Lindeza et al, 2020). Besides, restricted personal life and reduced social network interaction are common among informal caregivers (Carers UK, 2014; Lindeza et al, 2020). The consequent social isolation/exclusion only adds to the emotional and physical struggles described above. Moreover, objective burden relates to loss of labour productivity (LLP), which represents the financial gains that are missed as a result of providing informal care instead of being in paid employment (Farré et al., 2018).

Caring for a person with dementia is especially hard, taking the nature of the disorder into account. As dementia progresses, the need for care and supervision increases. This qualifies dementia as one of the most severe health problems in older age, which makes it especially burdensome for caregivers (Chiao et al., 2015). Informal caregiving of PwD who live alone instead of in a nursing home or with others might be most challenging due to the full responsibility of the informal care provider. Without the help of formal caregivers or others who live together with the PwD, informal caregivers are required to be constantly

reachable in case of emergencies and to support their loved one in any respect. Dementia-related factors that were shown to increase caregiver burden are mainly challenging behaviour, changes in temperament, and severity of the symptoms (Brodaty et al., 2014; Chiao et al., 2015; van den Kieboom et al., 2020). Thus, it is reasonable to assume that the experienced informal caregiver burden increases as dementia progresses. Moreover, Bertand et al. (2006) showed that informal caregivers of PwD score higher on measures of depression and overall burden compared to informal caregivers that do not have to deal with dementia.

To facilitate informal caregivers' wellbeing while ensuring extended independent living, eHealth technologies that support informal caregiving might be utilised. eHealth encompasses communication and information technologies that have the potential to facilitate and reform current healthcare practices and the healthcare system as a whole (Oh et al., 2005). Generally, such technologies are designed to support and reinforce humans instead of replacing them (Oh et al., 2005). eHealth is said to be "some form of technology to self-monitor your activity, communicate with different people about health and health conditions, coordinating care within the health system, and actively using technology to provide intervention" (Shaw et al., 2017). Based on that, its implementation is not limited to healthcare institutions, but eHealth might be used in daily life and in the context of in-home care. An example of eHealth that is suitable in dementia home care is monitoring technologies. They enable informal caregivers to monitor cognitive, behavioural, and bodily parameters of their loved ones without the need for being constantly present (Tiersen et al., 2021). Thus, they are designed to support informal caregivers in their effort to provide adequate care and recognise emergency situations early on (Wrede et al., 2021).

Even though innovative technologies offer many benefits, people tend to take a rather critical stance when it comes to eHealth, which might be explained by a combination of factors (Juma, 2016). Van Gemert-Pijnen et al. (2011) divided different types of implementation issues to describe the barriers regarding dissemination and continuous usage of eHealth technologies. The following technology shortcomings were distinguished: (1) lack of incentives to use, (2) lacking technology skills, (3) lacking motivation to start using the technology, (4) lacking confidence in one's ability to use it, (5) lacking ability of the technology to interoperate with other devices, and (6) unclear regulations. To account for these potential issues, a new holistic approach was introduced (van Gemert-Pijnen et al., 2011). It is considered a participatory design method since all relevant stakeholders are consulted in the design and evaluation process. The human-centred fashion of the approach

ensures that the needs and wishes of potential future users are accounted for, taking the technology shortcomings described above into account. Thus, a similar procedure should be adopted to facilitate widespread implementation of the technology for dementia home care.

To give an overview of the different types of monitoring devices, it should be distinguished between obtrusive and unobtrusive technologies (Sharma et al., 2021). Obtrusive systems encompass vision-based and wearable systems, smartphones, as well as audio-based systems that record and analyse semantics and real voices. Vision- and audio-based technologies are mainly problematic in terms of obtrusiveness, privacy, and autonomy (Berridge & Wetle, 2019; Zwijsen et al., 2011). Furthermore, since wearables or other smart devices are only reliable when the PwD wears/uses the system continuously and properly, which can often not be assured, such systems do not constitute a convenient solution to support informal caregivers of PwD (Oguntala et al., 2019). In contrast, unobtrusive technologies are commonly infra-red and radiofrequency (RF)-based sensing systems. Infra-red technologies are more suitable for short-range human activity recognition (HAR), whereas radiofrequency systems operate on long-range and can recognise small-scale human activities. RF-based systems use higher and lower frequencies, depending on the type of activities that is to be monitored, i.e., sensitive information like vital signs versus activities of daily life (ADLs) like personal hygiene and nutrition intake, respectively (Sharma et al., 2021). Based on that, radiofrequency has the potential to support providing in-home care for someone with dementia in various situations.

From the qualitative study of Wrede et al. (2021), different monitoring goals were elicited, which RF-based sensing systems can fulfil to support and relieve informal caregivers of persons with dementia. Following, the technology might be utilised to monitor (1) safety-related aspects, (2) health-related aspects, (3) physiological states, (4) risk predictions, and (5) psychosocial states. Safety-related aspects are mainly concerned with fall and wandering detection, meaning they are suited for acute situations. In contrast, health-related aspects describe non-acute situations that have the potential to become acute, e.g., in case of insufficient nutrition and fluid intake. Furthermore, behaviour and wellbeing during the night is a central aspect of in-home dementia care, which can be monitored with RF-based sensors that recognise irregularities and notify caregivers in case of issues. Physiological aspects are monitored to reliably recognise cognitive and physical deterioration in the long term, which facilitates taking actions early on when the PwD's condition declines. Moreover, risk predictions based on walking patterns and speed information are possible. Lastly,

psychosocial factors are part of the identified monitoring goals, which compromise emotional states, apathy, social interactions, as well as behaviour patterns and frequencies (e.g., leaving the house or using the phone).

To follow up on the study's results, a quantitative study design might be suitable to enrich the scientific knowledge base concerning eHealth for in-home dementia care. First, the derived monitoring goals might be further investigated to confirm their relevance in this context. Second, factors that were shown to hinder implementation of eHealth technologies might be considered to counteract these effects. For example, technology acceptance seems to be central, but acceptance ratings regarding unobtrusive monitoring systems were demonstrated to vary (Cohen-Mansfield & Biddison, 2007; Kang et al., 2010). Thus, further insight into the level of acceptance and the consequences for implementation of the technology is needed. Moreover, Davis & Venkatesh (1996) acknowledged that when a technology is considered of limited usefulness, people are less inclined to use it and the chances that they will make use of it are commonly low. Thus, the role of perceived usefulness for acceptance ratings, intention to use the technology, and adoption in practice seems to be crucial to investigate regarding this particular monitoring system. Even more, differences in acceptance and perceived usefulness concerning the different monitoring goals provided by Wrede et al. (2021) might help to focus the technology design on more acceptable and useful situations.

Research questions

- 1. What is the acceptance towards radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*
- 2. What is the perceived usefulness towards radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*
- 3. Is there a difference in acceptance and perceived usefulness of radiofrequency-based in-home monitoring technologies in regard to different care situations?*
- 4. To what extent is perceived usefulness associated with acceptance of radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*

Methods

Design

A quantitative-based cross-sectional study design was chosen to investigate the user acceptance of informal caregivers of PwD towards radiofrequency-based in-home monitoring technologies and the relationship with perceived usefulness of the technologies in different care situations.

Participants

The inclusion criteria for taking part in the study were as follows: (1) being 18 years or older, (2) being an informal caregiver as defined in the questionnaire, i.e., “Someone who provides voluntary (unpaid) care/help to someone close to them. An informal caregiver may be a spouse, son/daughter, other family member, or a friend” (Appendix A), (3) the person that is cared for has dementia or mild cognitive impairment. Purposive sampling was used in the form of a collaboration with German and Dutch Alzheimer’s associations, which distributed the survey within their informal caregiver networks and on their social media platforms. Moreover, convenience and snowball sampling was employed, whereby the researchers reached out to their social networks to gather participants and permitted/suggested forwarding the survey to interested informal caregivers from their respective social networks.

Materials

An online survey study was utilised to collect data about respondents’ acceptance towards in-home technology for dementia care (Appendix A). A total of 109 questions were included. The software Qualtrics was used to distribute the survey.

Scenarios

For the survey, specific scenarios were designed to examine differences in acceptance in regard to different care situations. In total, five scenarios inspired by the work of Wrede et al. (2021) were adopted for this study and cover the following aspects of dementia care: (1) acute safety-related situations, (2) safety-related risk predictions, (3) self-care behaviour, (4) nocturnal wellbeing, (5) monitoring of long-term patterns. Acute situations relate to emergency situations associated with falling and wandering. Risk prediction is designed to

inform authorised caregivers in case of an increased likelihood of emergency situations based on long-term walking patterns in a preventive manner. Self-care behaviour relates to ADLs like getting dressed, personal hygiene, and nutrition and fluid intake. Monitoring of nocturnal wellbeing is crucial to ensure PwD are in a good condition when no caregiver is present during the night. Lastly, analysis of long-term patterns is presented, which is aimed at providing information about changes in cognitive and physical condition.

Respondent characteristics

Respondents were asked to state their age in years, which was measured on a continuous scale, while gender, educational level, and country of residence were enquired using a nominal measurement. Following, a question was included to make sure the participants provide unpaid care for a relative or friend with dementia, which qualifies them to be considered an informal caregiver, using a nominal scale measurement. Moreover, reasons for informal care and relation to the PwD were treated as nominal, whereas the size of the caregiver network and geographical distance were treated as interval and ordinal, respectively. Lastly, questions regarding the care recipient were included. Age of the care recipient and first occurrence of dementia-related symptoms were measured in years, on a continuous and ordinal scale, respectively. Type of dementia, housing and living situation, and professional care services received by the PwD were considered nominal.

Acceptance

Acceptance of in-home monitoring technologies was assessed in three different ways. First, acceptance per scenario was measured, followed by acceptance towards different monitoring devices, and finally, the general acceptance towards radiofrequency-based in-home monitoring technologies was investigated. However, only the acceptance per scenario was relevant within the scope of this report.

Acceptance with regard to different care situations

Acceptance of the monitoring technology for each scenario was measured with two items on an interval measurement level using a 5-point Likert scale, ranging from 1 (= strongly disagree) to 5 (= strongly agree). One item covered technology acceptance of the informal caregiver, whereas the other item covered technology acceptance from the care recipient's point of view. An example item would be: 'I consider it acceptable to collect this type of information, using the system'.

Perceived usefulness

Perceived usefulness was assessed with seven items per scenario on a 5-point Likert scale ranging from 1 (= strongly disagree) to 5 (= strongly agree). An example of the items would be: “Such a monitoring system will enable me to feel reassured about the situation of my loved one.” The scale was utilised for all five scenarios in the questionnaire, which is why Cronbach’s alpha was calculated for each occasion the scale was applied. Cronbach’s alpha ranges from .938 to .968, which means that the scale has an excellent internal consistency (Table 1).

Table 1

Cronbach’s α for the perceived usefulness items per scenario

	Cronbach’s α
Perceived usefulness items concerning acute safety-related situations	.938
Perceived usefulness items concerning safety-related risk predictions	.942
Perceived usefulness items concerning self-care behaviour	.958
Perceived usefulness items concerning nocturnal wellbeing	.955
Perceived usefulness items concerning monitoring of long-term patterns	.968

Procedure

Initially, the questionnaire was designed in English language. Since the target group of the study are German and Dutch informal PwD caregivers, the questionnaire was translated to German (Appendix A) as well as Dutch. As a first step, the translation software DeepL was used to translate the English version to German and Dutch. Afterwards, the researchers proofread the translated versions and adapted them if necessary. Finally, the questionnaires were checked by the project leaders before it was approved to distribute the survey. Moreover, prior to data collection, ethics approval was granted by the BMS Ethics Committee from the University of Twente (request number 220421). Participants who decided to take part by clicking on the link were led to the introduction page providing information about the study and researcher contact details in case of questions or remarks. After providing informed consent, respondents were guided to the actual questionnaire. First, participant characteristics were queried to describe the informal caregivers, followed by questions about the person they care for. Second, questions assessing caregiver burden, digital literacy, innovativeness, and experience with technology were employed to provide input for the analysis of factors investigated by fellow researchers. Next, in-home monitoring technologies were introduced

through a written description along with an illustrative overview of the monitoring goals, setup of the system, and information output provided by the monitoring system. After indicating a sufficient understanding of the descriptions, the five scenarios were presented. Following each scenario, questions about the perceived usefulness, acceptance, and willingness to use the technology for this purpose specifically were included. Afterwards, items assessing perceived benefits and concerns, acceptance towards different monitoring technologies, and overall acceptance were presented. When they reached the end of the questionnaire, respondents were informed about their answers being recorded and they were thanked for their participation. Moreover, they were invited to state their email address to take part in the lottery to win one of four 10€ vouchers and researcher details were once again provided to give the opportunity to ask questions or give remarks.

Data analysis

For data analysis, IBM SPSS Statistics (version 26) was utilised. Prior to analysing the data, it was checked if all responses complied with the inclusion criteria mentioned above. Additionally, responses that had missing values for at least one item of interest were excluded from the analyses. Moreover, it was checked if perceived usefulness per scenario, and acceptance per scenario are normally distributed by running the Shapiro-Wilk test. Since it was shown that the data significantly differs from a normal distribution, non-parametric tests were utilised instead of parametric tests to account for that (Appendix B).

For the first research question, i.e., “*What is the acceptance towards radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*”, responses to the questions concerning acceptance of the technology presented right before the different care scenarios were examined. Due to non-normality of the data, the median and interquartile range were calculated instead of the mean scale score and standard deviation.

For the second research question, i.e., “*What is the perceived usefulness towards radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*”, the same procedure as for the first research question was applied, taking responses to the questions concerning perceived usefulness of in-home monitoring technologies into account.

To scrutinise the third research question “*Is there a difference in acceptance and perceived usefulness of radiofrequency-based in-home monitoring technologies in regard to different care situations?*”, the Friedman test was applied for each scenario as an alternative to the repeated measures ANOVA, which would have constituted a suitable analysis for the within-group design in case of a normal distribution. Subsequently, to examine where the differences occurred, the Wilcoxon signed-rank test was utilised. Moreover, the Bonferroni correction was applied as multiple comparisons between scenarios were made regarding acceptance and perceived usefulness.

Lastly, to investigate “*To what extent is perceived usefulness associated with acceptance of radiofrequency-based in-home monitoring technologies in regard to different care situations from the perspective of informal caregivers of community-dwelling PwD?*” Spearman's rho was calculated for each scenario to examine the relationship between the two quantitative variables acceptance (dependent variable) and perceived usefulness (independent variable). Spearman's rank-order correlation constitutes the alternative to the simple linear regression analysis that would have been employed in the case of normally distributed data.

Results

In total, 197 people participated in the study, of which 79 finished the whole questionnaire and met the inclusion criteria. The participants' mean (sd) age was 53.6 (12.1) and three-thirds were female (N=59, 75%). Most of the participants came from Germany (N=53, 67.1%), care for their parent (N=54, 68.3%), and provide informal care for this person together with one other informal caregiver (N=31, 39.2%). The informal care recipients' mean (sd) age was 81.2 (9.1) and one-third of them are diagnosed with Alzheimer's disease (N=28, 35.4%). Most of the informal care recipients live in their own house or flat (N= 57, 72.2%), either alone (N=38, 48.1%) or with someone together (N=41, 51.9%). One-fourth of the PwD experienced the first dementia-related symptoms 1 - 2 years ago (Table 2).

Table 2

Socio-demographic characteristics of informal caregivers and their care recipients

Variable	n	%	M	SD
Informal caregiver age (in years)	79		53.8	12.1
Gender				
Male	20	25		
Female	59	75		
Other informal caregivers of the person with dementia				
None	22	27.9		
1 other	31	39.2		
2 others	14	17.7		
3 others	5	6.3		
4 or more others	7	8.9		
Informal care recipient age (in years)	79		81.8	9.1
Living situation of care recipient				
Alone	38	48.1		
With others	41	51.9		

Acceptance per scenario

To answer the first research question, the median (IQR) scores for the items assessing acceptance of in-home monitoring technologies per scenario were computed. The median (IQR) acceptance scores are displayed below (Table 3). The acute safety-related situation and nocturnal wellbeing had a median (IQR) rating of 3.5 (1.0). The other scenarios were perceived as less acceptable as indicated by a median of 3.

Differences in acceptance between scenarios

To check if acceptance differs between the five use scenarios, the Friedman test was conducted. The results revealed significant differences in terms of acceptance between different care situations, F_r or $\chi^2(4) = 29.10$, $p < .001$ (Table 3). Furthermore, to examine which specific use scenarios differ from the others, the Wilcoxon signed-rank test was applied, taking the Bonferroni correction into account. It was revealed that using the system in acute safety-related situations was considered significantly more acceptable than regarding the safety-related risk prediction scenario and the self-care behaviour scenario ($Z = -3.02$, $p = .003$; $Z = -4.48$, $p < .001$). Moreover, collecting information about self-care behaviour is considered significantly less acceptable than monitoring nocturnal wellbeing and long-term patterns ($Z = -3.21$, $p = .001$; $Z = -2.86$, $p = .004$) (Table 4).

Table 3

Differences in terms of acceptance between scenarios

	Acute safety-related situations	Safety-related risk predictions	Self-care behaviour	Nocturnal wellbeing	Monitoring of long-term patterns	p
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
Acceptance	3.5 (1.0)	3.0 (.5)	3.0 (1.0)	3.5 (1.0)	3.0 (1.0)	<.001

Table 4

Wilcoxon test results showing which care situations differ significantly in terms of acceptance from each other

	Acceptance Scenario 1	Acceptance Scenario 2	Acceptance Scenario 3	Acceptance Scenario 4	Acceptance Scenario 5
Acceptance Scenario 1	-	-	-	-	-
Acceptance Scenario 2	-3.02* ^a	-	-	-	-
Acceptance Scenario 3	-4.48* ^a	-2.05 ^a	-	-	-
Acceptance Scenario 4	-1.30 ^a	-1.29 ^b	-3.21* ^b	-	-
Acceptance Scenario 5	-2.66 ^a	-.07 ^a	-2.86* ^b	-1.76 ^a	-

Note: scenario 1 = acute safety-related situations; scenario 2 = safety-related risk predictions; scenario 3 = self-care behaviour; scenario 4 = nocturnal wellbeing; scenario 5 = monitoring of long-term patterns.

* $p < .005$.

a. Based on positive ranks

b. Based on negative ranks

Perceived usefulness per scenario

Moreover, the median (IQR) scores were calculated for the items measuring perceived usefulness of in-home monitoring technologies per scenario. The results indicate that the perceived usefulness is slightly increased regarding all use scenarios (Table 5). The acute safety-related situation has the highest rating in terms of perceived usefulness, whereas the scenarios concerning safety-related risk predictions and monitoring of long-term patterns have the lowest perceived usefulness rating.

Differences in perceived usefulness between scenarios

Furthermore, to determine if there are significant differences in terms of perceived usefulness between the five different scenarios, the Friedman test was conducted. The results indicate significant differences between different care situations, F_r or $\chi^2(4) = 10.04$, $p = .04$ (Table 5). To investigate where the differences occur between the use scenarios, the Wilcoxon

test was applied, again taking the Bonferroni correction into account. The output shows that the acute safety-related situation is significantly higher rated in terms of perceived usefulness compared to the nocturnal wellbeing scenario ($Z = -3.02, p = .004$). The other scenarios are not shown to be significantly different from each other in that regard (Table 6).

Table 5

Differences in terms of perceived usefulness (PU) between scenarios

	Acute safety-related situations	Safety-related risk predictions	Self-care behaviour	Nocturnal wellbeing	Monitoring of long-term patterns	p
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
PU	3.9 (1.0)	3.6 (.5)	3.7 (1.0)	3.7 (1.0)	3.6 (1.0)	.04

Table 6

Wilcoxon test results showing which care situations differ significantly in terms of perceived usefulness (PU) from each other

	Scenario 1 PU	Scenario 2 PU	Scenario 3 PU	Scenario 4 PU	Scenario 5 PU
Scenario 1 PU	-	-	-	-	-
Scenario 2 PU	-2.88 ^a	-	-	-	-
Scenario 3 PU	-1.81 ^a	-.64 ^b	-	-	-
Scenario 4 PU	-1.79 ^a	-.86 ^b	-.06 ^b	-	-
Scenario 5 PU	-3.02 ^{*a}	-.44 ^a	-1.67 ^a	-1.36 ^a	-

Note: scenario 1 = acute safety-related situations; scenario 2 = safety-related risk predictions; scenario 3 = self-care behaviour; scenario 4 = nocturnal wellbeing; scenario 5 = monitoring of long-term patterns.

* $p < .005$.

a. Based on positive ranks

b. Based on negative ranks

Association between perceived usefulness and acceptance

To investigate the association between user acceptance and perceived usefulness, Spearman's rank-order correlation was conducted for each scenario. The regression coefficients for perceived usefulness are visualised below (Table 7). The results indicate for scenarios 1 and 4 concerning acute safety-related situations and nocturnal wellbeing a significant moderate correlation between perceived usefulness and acceptance, whereas for the other three scenarios a strong significant correlation was found. Based on that, it is reasonable to assume that user acceptance of in-home monitoring technologies is at least moderately associated with perceived usefulness.

Table 7

Spearman's rank-order correlation for the association between acceptance and perceived usefulness per scenario

	df	r_s	p
Acute safety-related situations	77	.567	<.001
Safety-related risk predictions	77	.658	<.001
Self-care behaviour	77	.651	<.001
Nocturnal wellbeing	77	.492	<.001
Monitoring of long-term patterns	77	.771	<.001

Discussion

The aim of the study was to investigate the acceptance and perceived usefulness of in-home monitoring technologies based on radiofrequency among informal caregivers of PwD. The findings indicate that the acceptance is mostly neutral, so neither low nor high, whereas using the technology for acute safety-related situations and nocturnal wellbeing was considered slightly more acceptable. Moreover, it was revealed that the monitoring system is generally perceived as useful, especially when it comes to acute safety-related situations. Positive ratings regarding perceived usefulness for all five scenarios were demonstrated. Lastly, a significant link between acceptance and perceived usefulness of the RF-based sensing system was found, which suggests that the level of acceptance might depend on the perceived usefulness.

Within the literature, differences in terms of acceptance of in-home monitoring systems for dementia care were observed. Whereas some report higher levels of acceptance, others indicate rather low acceptance rates among informal caregivers (Cohen-Mansfield & Biddison, 2007; Kang et al., 2010). As the current study reveals, monitoring systems are neither seen as acceptable nor unacceptable among the sample, but higher acceptance was observed regarding monitoring acute safety-related situations and nocturnal wellbeing. This leads to suggest that people might adjust their judgement of the technology according to the urgency of the situation. Cain & Mittman (2002) investigated the diffusion of innovation in the context of healthcare and acknowledged the role of relative advantage with regard to technology adoption. Relative advantage relates to the increasing adoption rates as a result of perceived value and benefit that comes along with the implementation of the technology. When interpreting the results of this study in the light of this concept, the added value of the monitoring technology for acute safety-related situations seems consistent with the findings regarding the diffusion of innovation (Cain & Mittman, 2002).

Since the overall acceptance of the presented technology was demonstrated to be neither high nor low, it leads to question if there are better alternatives to the radiofrequency-based monitoring system. Rijkonen et al. (2010) revealed that monitoring systems that are unobtrusive and do not require the person with dementia to interact actively with the technology are rated highest in terms of acceptance and usefulness. Thus, apparently radiofrequency-based monitoring systems are currently the best technological option to support informal caregivers by monitoring the various aspects of PwDs' daily living.

Moreover, the association that was proven to exist between user acceptance and perceived usefulness in the context of this study, was already discussed in the work of Davis & Venkatesh (1989). The concept of perceived usefulness was recognised as a key determinant of technology acceptance, which was shown to be the case in the context of eHealth appliances for dementia care. Thus, it is reasonable to assume that improving aspects of the perceived usefulness will likely affect acceptance rating positively.

Despite careful survey construction and vigilant data analysis, some limitations can be identified. A potential sampling bias was recognised that might result from lacking access to the internet among the population of informal caregivers. A study including roughly 1500 informal caregivers of people with dementia from the Netherlands showed that more than 53% of the informal caregivers are at least 65 years old (Zwaanswijk et al., 2013). Access to the internet among the Dutch for the age group 65 – 75 years was shown to be 94.5% in 2019, whereas only 77.2% of Dutch persons who are 75+ years old have access (Johnson, 2021). Hence, it seems reasonable to assume that a substantial part of the target group of informal caregivers was systematically neglected, implicating the validity of the study. Moreover, it might be argued that the respondents do not represent the actual target group of the monitoring technology, namely people with dementia who are living alone. As nearly 52% of the care recipients were shown to live with other people together, it can be argued that the studied sample did not represent the intended target group. This might affect the results concerning the perceived usefulness of the technology as those who live with the PwD might be less dependent on technological surveillance. Due to the informal caregiver's presence, the added value of such a monitoring system might be significantly less compared to informal caregivers of PwD who are frequently alone at home. Hence, it is reasonable to presume that the results underestimate the actual usefulness of the technology as perceived by informal caregivers of PwD who live alone. Lastly, even though the internal consistency of the scales used was shown to be excellent, it might be assumed that the reliability is negatively affected. Due to the non-existence of the monitoring technology, people might have failed to arrive at a thorough understanding of its purpose and functioning. To account for this nature, scenarios were utilised that might have counteracted the limited method of self-report concerning a non-existing technology. Unfortunately, nearly half of the participants indicated that they either did not understand the description or that things are still unclear to them. Thus, more sophisticated explanations and depictions of the central technology should be designed to counteract any response biases that arise due to lacking understanding.

As stated above, two scenarios seem to be of special importance, i.e., acute safety-related situations and nocturnal wellbeing. Hence, it would be wise to lay the focus on these and similar use situations, not only in terms of further research but also in the development and design process of the monitoring system. To ensure that the technology is in line with user expectations and demands, a user-centred design should be employed (Gemert-Pijnen, et al., 2011). Central aspects of this framework are, inter alia, stakeholder involvement, continuous evaluation, and prototyping. Hence, various stakeholders should be consulted, especially informal caregivers of PwD and their care recipients. By doing that, it is ensured that the user perspective is considered since they are the people who will use the final technology. When their needs and wishes are neglected, it might lead them to reject the monitoring system, e.g., because it is of limited usefulness for their care provision. Furthermore, repeated evaluation ensures that all flaws and issues are addressed before the final technology is developed and distributed. Also in this phase, consulting informal caregivers is vital to integrate their perspective regarding strong aspects and potential problems. A useful tool to evaluate technologies is prototyping, which allows to use the technology and experience their features in action. Ultimately, the uptake and impact of eHealth technologies are shown to be facilitated by using such a holistic framework, which would have positive implications in terms of caregiver relief and extended independent living. Moreover, the findings of this and future studies and developments are not only applicable to Germany and the Netherlands but could have implications for home care of people with dementia around the world. Thus, although the population of this study only includes Germans and Dutch people, the findings are not limited to these nations.

Overall, the results of the study provide valuable input for further research. Based on these insight, aspects of the technology might be improved with the aim to enhance user acceptance and, thus, facilitate adoption by informal caregivers and PwD. First of all, a mixed-methods approach, including quantitative and qualitative study components, should be favoured. From this study, inferences about informal caregivers' ratings of acceptance and perceived usefulness of the technology can be made. However, thoughts and attitudes behind the respondents' answers remain unknown due to the quantitative nature. Qualitative approaches, e.g., personal interviews, could potentially reveal the underlying reasoning and gather additional input from the perspective of those who provide informal care. Based on the diverse outcomes, a more informed design decision could be selected, and further research could dive deeper into aspects that were shown to be relevant in the interviews. Moreover, reaching out to Alzheimer's associations and providing paper and pen versions of the

questionnaire could ensure that the sample is representative of the population of informal caregivers that is to be researched. Also, more extensive scenarios in consultation with the recommendations gathered in this study should be designed, ideally as naturalistic and realistic as possible. Furthermore, based on the apparent association between acceptance and perceived usefulness, multivariate analyses with other variables that seem to play a role should be employed. Hence, more complex associations including confounding and/or mediating variables could be established.

In-home monitoring systems for dementia care have the potential to revolutionise caring for a loved one living at home. Using the technology might assist monitoring the condition of those with dementia while providing reassurance on part of the informal caregiver. Thus, relieving informal caregivers and enabling extended independent living for PwD becomes feasible through these technological advances. Despite the vast potential, aspects that might hinder implementation and uptake of the final technology need to be investigated to account for concerns and flaws in advance. The current study revealed that employing the technology to monitor acute safety-related situations and nocturnal wellbeing seems most important to informal caregivers. Moreover, the link between acceptance and perceived usefulness was identified. However, further research should tie up to these implications to enrich these findings. Ultimately, by utilising a holistic approach and involving informal caregivers and PwD in the development and evaluation process, the implementation of RF-based monitoring systems could be reinforced.

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Appendix A

Questionnaire in German language

Akzeptanz von Überwachungstechnologien in der Pflege älterer Menschen

Vielen Dank für Ihr Interesse an der Teilnahme an dieser Studie über den Einsatz von Technologien in der häuslichen Pflege. Die Studie wird von Psychologie-Studenten der Universität Twente im Rahmen ihrer Bachelor-Arbeiten durchgeführt.

Ziel der Studie ist es, herauszufinden, wie pflegende Angehörige über die Nutzung von Überwachungstechnologien für die Pflege älterer Menschen denken. Pflegende Angehörige sind Personen, die unbezahlte Unterstützung/ Pflege für ein Familienmitglied, einen Freund oder einen Nachbarn leisten. Wenn Sie ein pflegender Angehöriger einer älteren Person, einer Person mit Demenz oder leichter kognitiver Beeinträchtigung sind, sind Sie herzlich eingeladen, an unserer Studie teilzunehmen. Die Teilnahme wird etwa 20 Minuten dauern.

Ihre Angaben werden anonym verarbeitet, sodass diese nicht auf einzelne Personen zurückgeführt werden können. Die erhobenen Daten werden ausschließlich für wissenschaftliche Forschungszwecke verwendet und nicht an Dritte weitergegeben.

Ihre Teilnahme an dieser Studie ist freiwillig und Sie können jederzeit ohne Angabe von Gründen von der Teilnahme zurücktreten. Sollten Sie Fragen zur Studie haben, können Sie sich gerne an Ronja Rosenkranz, eine der Student*innen, oder Frau Dr. Braakman-Jansen, die Projektleiterin, wenden.

Um Ihnen für Ihre Teilnahme zu danken, haben Sie am Ende des Fragebogens die Möglichkeit einen 10€ Mydays Gutschein zu gewinnen.

Einverständniserklärung

Ich bestätige, dass ich 18 Jahre alt bin und mit der oben beschriebenen Verarbeitung der Daten einverstanden bin. Ich nehme freiwillig an dieser Studie teil.

- Ja
- Nein

TEIL 1: Allgemeine Fragen zu Ihrer Person

Vielen Dank. Wir möchten gerne mit einigen Fragen zu Ihrer Person beginnen.

Wie alt sind Sie (in Jahren)?

Mit welcher der folgenden Optionen identifizieren Sie sich am meisten?

- Männlich
- Weiblich
- Anders/ keine Angabe

In welchem Land leben Sie?

- Niederlande
- Deutschland
- Keine der genannten Optionen trifft zu

Sind Sie ein pflegender Angehöriger/ eine pflegende Angehörige?

(Pflegerische Angehörige sind Personen, die unbezahlte Pflege/ Unterstützung für ein gesundheitlich eingeschränktes Familienmitglied (z.B. Partner oder Eltern), einen Freund oder Nachbarn leisten.)

- Ja
- Nein

Was ist der Grund für die Pflege/ Unterstützung? (mehrere Antworten sind möglich)

- Demenz oder leichte kognitive Beeinträchtigung/ Gedächtnisstörungen
- Folgen des normalen Alterungsprozess
- Somatische Beeinträchtigung
- Psychische Krankheit
- Andere Gründe

Was beschreibt die Beziehung zu der Person, die Sie pflegen/ unterstützen, am besten?

Ich bin...

- (Ehe)partner
- Tochter/ Sohn
- Schwiegertochter/-sohn
- Schwester/ Bruder
- Nachbar(in) / Freund(in)
- Enkel(in)
- Anders, nämlich _____

Gibt es weitere pflegende Angehörige, die an der Pflege/ Unterstützung Ihres Angehörigen beteiligt sind?

- Nein, ich bin die einzige Person
- Ja, 1 weitere Person
- Ja, 2 weitere Personen
- Ja, 3 weitere Personen
- Ja, 4 oder mehr andere Personen

Bitte geben Sie an, wie lange Sie brauchen, um zu der Wohnung der Person zu gelangen, die Sie pflegen/ unterstützen. Bitte beziehen Sie sich dabei auf das Fortbewegungsmittel, welches Sie überwiegend für diese Strecke nutzen (z.B. zu Fuß, Fahrrad, Bus, Bahn, Auto etc.)

Wie weit leben Sie von der Person, die Sie pflegen/ unterstützen, entfernt?

- Ich lebe im gleichen Haus
- Ich lebe zwischen 1 und 5 Minuten entfernt
- Ich lebe zwischen 6 und 15 Minuten entfernt
- Ich lebe zwischen 16 und 30 Minuten entfernt
- Ich lebe zwischen 31 Minuten und 1 Stunde entfernt
- Ich lebe mehr als 1 Stunde entfernt

TEIL 2: Allgemeine Fragen zu Ihrem/ Ihrer Angehörigen

Im Folgenden möchten wir Ihnen einige Fragen stellen zu Ihrem/ Ihrer Angehörigen, welche(n) Sie pflegen/ unterstützen.

Wie alt ist die Person, die Sie pflegen/ unterstützen (in Jahren)?

Welche Art von Demenz oder kognitiver Beeinträchtigung betrifft die Person, die Sie pflegen/ unterstützen?

- Alzheimer
- Lewy-Body-Demenz bzw. Lewy-Körper-Demenz
- Vaskuläre Demenz
- Leichte kognitive Störung
- Eine andere Art von Demenz/ ich weiß es nicht
- Es wurde (noch) keine Diagnose festgestellt

Seit wann hat die Person, die Sie pflegen/ unterstützen, Symptome einer Demenz oder einer leichten kognitiven Beeinträchtigung (Schätzung)?

- Weniger als 1 Jahr
- 1 bis 2 Jahre
- 2 bis 3 Jahre
- 3 bis 4 Jahre
- 4 bis 5 Jahre
- Länger als 5 Jahre

Wie ist die aktuelle Wohnsituation der Person, die Sie pflegen/ unterstützen?

- Die zu betreuende Person lebt allein
- Die zu betreuende Person lebt mit anderen Personen zusammen

Wo wohnt die Person, die Sie pflegen/ unterstützen?

- In einem eigenen (Miet-)Haus / einer eigenen (Miet-)Wohnung
- In dem Haus/ der Wohnung eines Familienmitglieds
- In einer (betreuten) Seniorenwohnung oder einer Wohnung, die zu einer Gesundheitseinrichtung gehört
- In einem Pflegeheim
- Anders, nämlich: _____

Welche Art von professioneller Pflege/Dienstleistung erhält Ihr Angehöriger? (Mehrere Angaben möglich)

- Häusliche Pflege durch eine Krankenschwester oder einen Pfleger
- Eine feste Ansprechperson welche die Pflege Ihres Angehörigen koordiniert
- Tagespflege/ Tagesbetreuung
- Hilfe für den Haushalt
- Essen auf Rädern
- Keiner der oben genannten Optionen

TEIL 3: Wahrgenommene Belastung durch die Pflege

In diesem Teil des Fragebogens interessieren wir uns für die Belastung, die Sie durch die Pflege/ Unterstützung Ihres Angehörigen möglicherweise erfahren.

Caregiver burden scale

TEIL 4: Digitale Kompetenz, Innovations-Affinität & Erfahrung mit Technologien

Ich experimentiere gerne mit neuen Technologien.



Welche der folgenden Technologien nutzen Sie derzeit oder haben Sie in der Vergangenheit bereits genutzt?

- Technologien zur Überwachung der täglichen Aktivitäten/des Lebensstils Ihres Angehörigen (z.B. Sensortechnologie, Alarmknöpfe, GPS-Tracker)
- Digitale Kommunikationstechnologie, um mit Ihrem Angehörigen in Kontakt zu bleiben (z.B. Videoanrufe, Nachrichten Systeme, WhatsApp)
- Technologie zur Unterstützung des Gedächtnisses oder der Tagesstruktur Ihres Angehörigen (z.B. Erinnerungssysteme, Smartwatch (elektronische Multifunktions-Armbanduhr), automatischer Medikamentenspender (der die Einnahme von Medikamenten kontrolliert))
- Digitale Pflegeplattformen zur Unterstützung der Koordination der Pflege Ihres Angehörigen (z.B. Plattformen zur Erleichterung der Kommunikation zwischen informellen und professionellen Pflegekräften)
- Keine der oben genannten Technologien

TEIL 5: Kontaktlose Überwachungstechnologie in der Pflege Angehöriger

Bitte sehen Sie sich die folgende Beschreibung und Illustration an, bevor Sie mit den nächsten Fragen fortfahren.

Es werden immer mehr Technologien entwickelt, die darauf abzielen, pflegende Angehörige zu unterstützen und es ihren Angehörigen zu ermöglichen, länger zu Hause zu leben. In diesem Teil des Fragebogens konzentrieren wir uns auf eine spezielle Form der unterstützenden Technologie: kontaktlose Überwachungstechnologien.

Bei kontaktloser Heimüberwachungstechnologie handelt es sich um ein Sensorsystem, das in der Wohnung älterer Personen installiert werden kann und rund um die Uhr Informationen über deren Lebensstil, Gesundheit und Sicherheit liefert. Die Technologie soll dem pflegenden Angehörigen einen besseren Einblick in die Situation des älteren Menschen geben, insbesondere wenn der pflegende Angehörige weit entfernt wohnt oder das Haus verlässt.

Die Technologie funktioniert kontaktlos, d.h. ältere Menschen müssen keine Geräte tragen. Wie in dem Bild zu sehen ist, kann eine kleine Box mit eingebauten Sensoren in einer Ecke der Wohnung platziert werden. Mit Hilfe künstlicher Intelligenz kann dieses System lernen den täglichen Lebensstil Ihres Angehörigen zu erkennen und wichtige Veränderungen zu signalisieren, wie z.B. weniger essen und trinken oder nächtliche Unruhe. In Notfällen (z.B. Sturz) kann das System den pflegenden Angehörigen alarmieren. Die gesammelten Informationen können in Echtzeit auf einer digitalen Plattform angezeigt werden, auf die der pflegende Angehörige, die pflegebedürftige Person und, falls gewünscht, das medizinische Fachpersonal aus der Ferne zugreifen können.

Wie verständlich fanden Sie die obige Beschreibung und die Bilder über die kontaktlose Heimüberwachungstechnologie?

- Nicht klar
- Ziemlich klar
- Eindeutig

Haben Sie Vorschläge, wie man die Klarheit der Beschreibung verbessern kann?

5A: Verschiedene Nutzungsszenarien

Im Folgenden werden Ihnen 5 verschiedene Szenarien vorgestellt. Die Szenarien sind Beschreibungen von Situationen, in denen kontaktlose Überwachungstechnologie in der häuslichen Pflege eingesetzt werden könnte. Alle Szenarien enthalten verschiedene Aspekte, die überwacht werden können. Bitte beantworten Sie die folgenden Fragen für jedes Szenario.

Szenario 1: Erkennen von Notsituationen

Stellen Sie sich Folgendes vor: In der Wohnung Ihres Angehörigen wird eine kontaktlose Überwachungstechnologie installiert. Diese Technologie überwacht kontinuierlich sicherheitsgefährdende Aspekte, wie z.B. Stürze oder Umherirren. Es kann solche Notsituationen in Echtzeit erkennen und Sie oder eine andere autorisierte Person alarmieren.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zu Szenario 1 zustimmen:

Kontaktlose Überwachungstechnologie zur Erkennung von Notsituationen meines Angehörigen...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
...würde ich akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mein Angehöriger akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...wäre nützlich für mich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mich dabei unterstützen, die bestmögliche Pflege für meinen Angehörigen zu leisten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mich dabei unterstützen, mich über die Situation meines Angehörigen rückzuversichern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mir dabei helfen, schneller auf die Pflegebedürfnisse meines Angehörigen einzugehen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde dazu beitragen, dass mein Angehöriger länger zu Hause leben kann.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mir dabei helfen, in meiner Rolle als pflegender Angehöriger länger durchzuhalten.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

...würde mir Informationen liefern, die ich mit der/den medizinischen Fachkräft(en) meines Angehörigen teilen möchte.

Ich würde die kontaktlose Überwachungstechnologie zur Erkennung von Notsituationen meines Angehörigen in (naher) Zukunft nutzen wollen.

Szenario 2: Risikovorhersagen

Stellen Sie sich Folgendes vor: In der Wohnung Ihres Angehörigen wird eine kontaktlose Überwachungstechnologie installiert. Diese zielt darauf ab, akute Situationen nicht nur zu erkennen, sondern vorherzusagen. So kann die Technologie z.B. kontinuierlich die Gehgeschwindigkeit und das Gehverhalten Ihres Angehörigen überwachen. Anhand dieser Informationen kann das System das Sturzrisiko vorhersagen und Sie oder eine andere autorisierte Person darüber informieren. Das Ziel ist es, Notsituationen wie z.B. Stürze zu verhindern.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zu Szenario 2 zustimmen:

Kontaktlose Überwachungstechnologie zur Vorhersage von Risiken meines Angehörigen...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
...würde ich akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mein Angehöriger akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

...wäre nützlich für mich

...würde mich dabei unterstützen, die bestmögliche Pflege für meinen Angehörigen zu leisten

...würde mich dabei unterstützen, mich über die Situation meines Angehörigen rückzuversichern

...würde mir dabei helfen, schneller auf die Pflegebedürfnisse meines Angehörigen einzugehen

...würde dazu beitragen, dass mein Angehöriger länger zu Hause leben kann.

...würde mir dabei helfen, in meiner Rolle als pflegender Angehöriger länger durchzuhalten.

...würde mir Informationen liefern, die ich mit der/den medizinischen Fachkräft(en) meines Angehörigen teilen möchte.

Ich würde die kontaktlose Überwachungstechnologie zur Vorhersage von Risiken meines Angehörigen in (naher) Zukunft nutzen wollen.

Szenario 3: Überwachung des Selbstpflegeverhaltens

Stellen Sie sich Folgendes vor: In der Wohnung Ihres Angehörigen wird eine kontaktlose Überwachungstechnologie installiert. Diese überwacht kontinuierlich die Selbstversorgung Ihres Angehörigen wie Essen, Trinken und Körperpflege (z. B. Baden, Toilettengang, Anziehen). Das System kann größere Abweichungen im Selbstpflegeverhalten erkennen und Benachrichtigungen an Sie oder eine andere autorisierte Person senden.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zu Szenario 3 zustimmen:

Kontaktlose Technologie zur Überwachung des Selbstpflegeverhaltens meines Angehörigen...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
...würde ich akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mein Angehöriger akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...wäre nützlich für mich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mich dabei unterstützen, die bestmögliche Pflege für meinen Angehörigen zu leisten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mich dabei unterstützen, mich über die Situation meines Angehörigen rückzuversichern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mir dabei helfen, schneller auf die Pflegebedürfnisse meines Angehörigen einzugehen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

...würde dazu beitragen, dass mein Angehöriger länger zu Hause leben kann.

...würde mir dabei helfen, in meiner Rolle als pflegender Angehöriger länger durchzuhalten.

...würde mir Informationen liefern, die ich mit der/den medizinischen Fachkräft(en) meines Angehörigen teilen möchte.

Ich würde die kontaktlose Überwachungstechnologie zur Überwachung des Selbstpflegeverhaltens meines Angehörigen in (naher) Zukunft nutzen wollen.

Szenario 4: Überwachung des Wohlbefindens während der Nacht

Stellen Sie sich Folgendes vor: In der Wohnung Ihres Angehörigen wird eine kontaktlose Überwachungstechnologie installiert. Diese überwacht kontinuierlich das Wohlbefinden Ihres Angehörigen während der Nacht. Das System kann Abweichungen (z. B. nächtliche Unruhe, Schlafprobleme oder einen gestörten Tag-Nacht-Rhythmus) erkennen und Benachrichtigungen an Sie oder eine andere autorisierte Person senden.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zu Szenario 4 zustimmen:

Kontaktlose Technologie zur Überwachung des Wohlbefindens meines Angehörigen während der Nacht...

Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
---------------------------	-----------------	---------	-----------	------------------

...würde ich akzeptabel
finden

...würde mein
Angehöriger akzeptabel
finden

...wäre nützlich für mich

...würde mich dabei
unterstützen, die
bestmögliche Pflege für
meinen Angehörigen zu
leisten

...würde mich dabei
unterstützen, mich über
die Situation meines
Angehörigen
rückzuversichern

...würde mir dabei helfen,
schneller auf die
Pflegebedürfnisse meines
Angehörigen einzugehen

...würde dazu beitragen,
dass mein Angehöriger
länger zu Hause leben
kann.

...würde mir dabei helfen,
in meiner Rolle als
pflegender Angehöriger
länger durchzuhalten.

...würde mir
Informationen liefern, die
ich mit der/den
medizinischen
Fachkräft(en) meines
Angehörigen teilen
möchte.

Ich würde die kontaktlose Überwachungstechnologie zur Überwachung des Wohlbefindens meines Angehörigen während der Nacht in (naher) Zukunft nutzen wollen.

Szenario 5: Überwachung von langfristigen Gesundheitsveränderungen

Stellen Sie sich Folgendes vor: In der Wohnung Ihres Angehörigen wird eine kontaktlose Überwachungstechnologie installiert. Diese überwacht mögliche Veränderungen des Gesundheitszustandes der Person, die sich im Laufe der Zeit entwickeln. Das System kann Sie oder eine andere autorisierte Person beispielsweise darüber informieren, ob es in einem bestimmten Zeitraum zu einer kognitiven oder körperlichen Verschlechterung gekommen ist.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zu Szenario 5 zustimmen:

Kontaktlose Technologie zur Überwachung langfristiger Gesundheitsveränderungen meines Angehörigen...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
...würde ich akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mein Angehöriger akzeptabel finden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...wäre nützlich für mich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...würde mich dabei unterstützen, die bestmögliche Pflege für meinen Angehörigen zu leisten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

...würde mich dabei unterstützen, mich über die Situation meines Angehörigen rückzuversichern

...würde mir dabei helfen, schneller auf die Pflegebedürfnisse meines Angehörigen einzugehen

...würde dazu beitragen, dass mein Angehöriger länger zu Hause leben kann.

...würde mir dabei helfen, in meiner Rolle als pflegender Angehöriger länger durchzuhalten.

...würde mir Informationen liefern, die ich mit der/den medizinischen Fachkräft(en) meines Angehörigen teilen möchte.

Ich würde die kontaktlose Überwachungstechnologie zur Überwachung langfristiger Gesundheitsveränderungen meines Angehörigen in (naher) Zukunft nutzen wollen.

5B: Erwartete Vorteile & Bedenken

Im Folgenden möchten wir Sie nach den von Ihnen erwarteten Vorteilen und Bedenken in Bezug auf kontaktlose Überwachungstechnologie fragen.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen:

Ich glaube, dass mir kontaktlose Überwachungstechnologie in der häuslichen Pflege helfen kann ...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
Zu überprüfen, ob mein Angehöriger angemessen für sich selbst sorgt (z.B. Essen, Trinken)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Nicht erforderliche Besuche zu vermeiden wie z.B. Besuche zur Kontrolle der Selbstpflege meines Angehörigen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mich bezüglich der Sicherheit meines Angehörigen zu vergewissern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meine Freiheit und Mobilität wiederzuerlangen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Faktoren, welche die Unabhängigkeit meines Angehörigen einschränken, zu erkennen und zu beseitigen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Schneller auf den
Pflegebedarf
meines
Angehörigen zu
reagieren, um
Gesundheitsrisike
n vorzubeugen
(z.B.
Unterernährung,
Schlafprobleme,
Einsamkeit)

○ ○ ○ ○ ○

Anderen Personen
(einschließlich
Pflegefachkräften)
einen objektiven
Einblick in die
Situation meines
Angehörigen zu
geben

○ ○ ○ ○ ○

Den optimalen
Zeitpunkt für den
Übergang meines
Angehörigen in
ein Pflegeheim
oder zu einer
anderen
Wohnform zu
finden

○ ○ ○ ○ ○

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen:

Wenn ich kontaktlose Überwachungstechnologie in der häuslichen Pflege einsetzen würde,
wäre ich ...

Stimme
überhaupt
nicht zu

Stimme
nicht zu

Neutral

Stimme
zu

Stimme
völlig zu

Besorgt, mit zu vielen Informationen überhäuft zu werden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Besorgt, dass die Überwachungsinformationen mich unnötig beunruhigen würden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Verunsichert, auf welche Informationen ich reagieren sollte	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Besorgt, dass Überwachungsdaten ohne unsere Zustimmung an Dritte weitergegeben werden könnten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Verunsichert, ob die Vorteile des Systems die Verletzung der Privatsphäre meines Angehörigen rechtfertigen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Besorgt, dass die Technologie den menschlichen Kontakt ersetzen könnte	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5C: Allgemeine Akzeptanz von kontaktloser Überwachungstechnologie

Nun interessieren wir uns für Ihre allgemeine Akzeptanz von kontaktloser Überwachungstechnologie in der häuslichen Pflege. Bitte berücksichtigen Sie alle Informationen, die Sie nun über die Funktion und den Einsatz dieser Technologien haben und geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen.

Ich denke, dass kontaktlose Überwachungstechnologie in der Pflege meines Angehörigen nützlich sein kann...

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme völlig zu
--	---------------------------	-----------------	---------	-----------	------------------

...zu diesem Zeitpunkt in meinem Leben

...wenn sich die kognitive oder körperliche Gesundheit meiner Pflegeperson verschlechtert

Ich würde kontaktlose Überwachungstechnologie in der Pflege meines Angehörigen nutzen wollen...

Stimme überhaupt nicht zu

Stimme nicht zu

Neutral

Stimme zu

Stimme völlig zu

...zu diesem Zeitpunkt in meinem Leben

...wenn sich die kognitive oder körperliche Gesundheit meiner Pflegeperson verschlechtert

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen zustimmen:

Stimme überhaupt nicht zu

Stimme nicht zu

Neutral

Stimme zu

Stimme völlig zu

Es ist eine gute Idee kontaktlose Überwachungstechnologie in der Pflege meines Angehörigen zu nutzen

Meine Familie und Freunde würden es gut finden, wenn ich bei der Pflege meines Angehörigen kontaktlose Überwachungstechnologie einsetzen würde

Die professionellen Pflegekräfte/medizinischen Fachkräfte meines Angehörigen würden es gut finden, wenn ich bei der Pflege meines Angehörigen kontaktlose Überwachungstechnologie einsetzen würde

Die an das Überwachungssystem angeschlossene digitale Plattform (App) bedienen zu lernen wäre leicht für mich

Ich denke, dass ich das nötige Wissen und die Unterstützung habe/ bekomme um kontaktlose Überwachungstechnologie in der Pflege meines Angehörigen zu verwenden

5D: Verschiedene Formen von Überwachungstechnologie

Wir sind nun beim letzten Teil des Fragebogens angelangt. Häusliche Überwachungstechnologie im Allgemeinen kann verschiedene Geräte/Sensoren einsetzen, um Informationen über die tägliche Situation einer pflegebedürftigen Person zu erfassen.

Diese Geräte variieren je nach Art des Kontakts mit dem Körper (kontaktlos, indirekter Kontakt, direkter Kontakt). Uns interessiert, was Sie von diesen Geräten halten.

Bitte geben Sie für jedes der unten aufgeführten Überwachungsgeräte an, inwiefern Sie dessen Einsatz für die Pflege Ihres Angehörigen für akzeptabel halten.

	Völlig inakzeptabel	Inakzeptabel	Neutral	Akzeptabel	Sehr akzeptabel
Tragbare Geräte (Technologie, die am oder in der Nähe des Körpers getragen wird, wie z.B. Smartwatches, Mobiltelefone, tragbare Alarmknöpfe)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Visuelle Geräte (z.B. Kameras, die anonymisierte Bilder erzeugen, d.h. Bilder, auf denen Gesichter nicht erkennbar sind)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Auf Ton basierende Geräte (z.B. Mikrophon, Smart Speaker)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Radiofrequenz
Geräte (z.B.
Sensoren, die an
einer zentralen
Stelle im Haus
angebracht werden
und
Bewegungsdaten
per Radar erfassen)

Objekt-gebundene
Technologie:
Sensoren, die an
Gegenständen des
täglichen
Gebrauchs
angebracht sind
(z.B.
Bewegungssensore
n an Türen, am
Kühlschrank oder
Drucksensoren an
der Bettmatratze)

Zum Schluss noch eine letzte Frage zu Ihrer Person:

Was ist der höchste schulische Abschluss, den Sie erworben haben?

- Grundschulabschluss oder kein Abschluss
- Haupt-/Realschulabschluss
- Abitur
- Berufsschulabschluss
- Bachelor-/ Masterabschluss oder Diplom
- Doktorgrad
- Keine der genannten Optionen trifft zu

Vielen Dank für Ihre Teilnahme! Sie haben jetzt die Möglichkeit, einen Preis zu gewinnen!

Wir danken Ihnen für Ihre Hilfe und Entscheidung, an unserer Studie teilzunehmen. Kennen Sie Freunde, Familienmitglieder oder Bekannte, die pflegende Angehörige sind und an dieser Studie teilnehmen könnten? Dann wären wir Ihnen sehr dankbar, wenn Sie diese Umfrage weiterleiten würden.

Als Dankeschön für Ihre Teilnahme haben Sie die Möglichkeit, einen 10-Euro-Mydays-Gutschein (falls Sie in Deutschland leben) oder einen Cadeaubon-Gutschein (falls Sie den Niederlanden leben) zu gewinnen. Insgesamt werden 4 Gewinner nach dem Zufallsprinzip verlost. Wenn Sie an der Verlosung teilnehmen möchten, können Sie uns hier Ihre E-Mail-Adresse hinterlassen.

(Die Daten werden ausschließlich zum Zweck der Kontaktaufnahme verwendet und getrennt von Ihren Antworten verarbeitet.)

Wir glauben, dass es sehr wichtig ist, pflegende Angehörige

in die Entwicklung und Verbesserung von unterstützender Technologie einzubeziehen. Dürfen wir Sie für zukünftige Forschung ansprechen? Falls gewünscht, können Sie uns hier Ihre E-Mail-Adresse hinterlassen.

(Die Daten werden ausschließlich zum Zweck der Kontaktaufnahme verwendet und getrennt von Ihren Antworten verarbeitet.)

Appendix B

Table B1

Test of Normality (Shapiro-Wilk)

	W	p
Perceived usefulness Scenario 1	.916	<.001
Perceived usefulness Scenario 2	.951	.004
Perceived usefulness Scenario 3	.931	<.001
Perceived usefulness Scenario 4	.922	<.001
Perceived usefulness Scenario 5	.937	.001
Acceptance Scenario 1	.935	<.001
Acceptance Scenario 2	.942	.001
Acceptance Scenario 3	.960	.015
Acceptance Scenario 4	.908	<.001
Acceptance Scenario 5	.937	.001