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Adoption and Determinants of Assistive Technologies in the Real World: Results from the VdK Study

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Abstract. Introduction While there is growing evidence of the benefits of assistive technologies little is known about their adoption under real circumstances and prevalence for everyday use. **Objective** The aim of this analysis therefore was (i) to investigate the adoption rates in the real world and (ii) to identify potential determinants of their adoption by care-dependant persons and family caregivers. **Methods** The present study is a secondary analysis based on the data set of the VdK study on home care arrangements (n=53,678). The analysis of the adoption rates included 22,666 care-dependant persons and caregivers, the identification of potential determinants via binary logistic regressions included 5,275 persons. **Results** Emergency call systems and technical (smart) aids reached an adoption rate of 40.4 % (care-dependant persons) and 55.3 % (family caregivers). Fall detectors, orientations aids, nursing apps and monitoring systems were used in less than 5 % of the cases. Care degree and the use of an ambulatory nursing service increased the likelihood of using technical aids. **Conclusion** It can be concluded that innovative and sophisticated types of assistive technologies are still rather scarcely used for home care arrangements in the real world despite large research efforts in the last twenty years.

Keywords. Home care, assistive technologies, family caregivers, care-dependant persons, ambulatory nursing services

1. Introduction

Following WHO's Global Cooperation on Assistive Technology, assistive technologies (products) embrace any type of device, equipment, instruments and software tool whose purpose is to contribute to the maintenance and improvement of one's health (functioning), independence and wellbeing [1]. These products are typically embedded into sensor and robot based smart home systems for health care, are stand alone or integrated wearables and mobile technologies, or telemedicine applications. They are meant to support scenarios where the elderly live a) alone, b) with family members, c) in nursing homes or d) in retirement communities [2]. In 2019, home care took place in 3.31 Mio. German households among which care was performed without professional

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support from nurses in more than 2 Mio households [3]. These challenges hint at the increasing significance and potential of assistive technologies.

Among those who are not yet in need of nursing care, there seems to be general acceptance of health-related home assistance systems. In this study on preparedness to use assistive technologies, frailty monitoring for persons with dementia reached the highest acceptance values. Prompting systems and the recognition of activities of daily living obtained mixed votes and particularly negative ratings when cameras were involved. For all specific technologies chronically ill showed a lower degree of acceptance than their healthy peers [4].

Evidence from RCT studies about the outcomes of using assistive technologies in realistic environments yielded mixed results. In comparison with technologies for mobility, medication, mental support, hearing and vision, technologies for personal disease management proved to be most effective: 4 out of the 5 RCT studies reported significant improvements. Personal disease management hereby improved the self-care behaviour and the quality of life in addition to decreased blood glucose or blood pressure values [5]. Another systematic review found that there was evidence for increased physical and mental well-being in the population of community-dwelling elderly who live alone due to employing assistive technologies but not for social well-being [6].

Already 10 years ago, assistive technologies were increasingly developed for family caregivers as well. The technologies improved their self-efficacy and ensured safer care through monitoring and telecare [7]. Whether assistive technologies really decrease the burden for caregivers or add burden is still under debate. One systematic review came to the conclusions that the studies mainly supported the assumption that assistive technologies helped caregivers to reduce time, level of assistance and energy required to carry out the care. This included activities demanding physical assistance [8]. Another systematic review concluded that all in all the studies found that the emotional and physical effort of caregivers could be diminished when using assistive technologies [9] which speaks in favour of relieving the caregivers from some burden.

While there is growing evidence and understanding of these technologies most of them are evaluated in lab situations or pilot studies and little is known about their adoption under real circumstances and prevalence for everyday use. By adoption we mean the availability and use of a technology.

The aim of this analysis therefore was (i) to investigate the adoption rates of different assistive technologies in the real world and (ii) to explore characteristics of the users, their physical and psychosocial environment as potential determinants of the adoption and non-adoption of assistive technologies.

2. Methods

2.1. The VdK Study on home care arrangements

Established over 70 years ago, the VdK is an independent German social community of citizens in the form of a registered society with 2.1 Mio members nationwide. Its mission is to inform the public and politics about socially relevant topics in old-age pension, healthcare, long-term care, participation and inclusion, barrier-free and accessible living and other areas of social justice [10].

The VdK commissioned the department of Nursing Science at Hochschule Osnabrück to conduct an exploratory study on the current situation of care at home

among its members. The study should reflect the view of caregivers, care-dependant persons and persons without experience in nursing care[2]. To this end two questionnaires were developed based on the literature. The one for care-dependant persons covered the following eight topics 1) demographics of the person, care needs and the care situation, 2) type and degree of the need for support, 3) utilization and satisfaction with support services, 4) living environment and technical support, 5) utilization and experience with nursing counselling, 6) impact of the Corona pandemic on the care situation, 7) general appraisal of the situation, 8) helpful circumstances and general demands for politics. The questionnaire for the caregivers also addressed these eight topics. Additionally, it included questions about the employment and demographics of the caregivers as well as the burden resting on them due to the care situation. Both questionnaires were issued to all VdK members via a web-survey tool (lime survey) which was open from March 29th to May 9th, 2021 [11] according to the time plan of the project.

A total of 53,678 persons answered the questionnaire of which there were 6,594 care-dependant persons (12.3%), 27,364 family caregivers (51.0%) and 19,720 persons without care experience (36.7%) [11]. Table 1 shows an overview of the sample characteristics.

Table 1: Sample characteristics of the VdK study [11].

* Care-dependant persons (382 of 5617 had no care degree or had applied for), care-dependant persons cared for by a family member (1018 of 23,307 had no care degree or had applied for)

Variable		**Care-dependant persons**			**Family caregivers**	
AGE: ≤ 40 years	N = 5,577	367	6.6 %	N = 23,339	3,038	13.0 %
AGE: 41 – 60 years		2,072	37.2 %		1,824	7.8 %
AGE: 61 – 80 years		2,581	46.3 %		6,641	28.5 %
AGE: > 80 years		557	10.0 %		11,836	50.7 %
CARE DEGREE*: 1	N = 5,617	780	13.9 %	N = 23,307	1,089	4.7 %
CARE DEGREE*: 2		2,293	40.8 %		5,533	23.8 %
CARE DEGREE*: 3		1,519	27.0 %		7,630	32.7 %
CARE DEGREE*: 4		486	8.7 %		4,819	20.7 %
CARE DEGREE*: 5		157	2.8 %		3,218	13.8 %

This sample represents about 2% of all VdK members. The distribution of the care degree of the care-dependant persons resembled that of the German population of persons with a care degree. In contrast, the care degree of persons cared for by the family caregivers deviated from the German population showing a lower percentage in care degree 2 and a higher representation in the degrees 3 to 5 [11].

The present study is a secondary analysis based on this data set. As not all questions were answered by everybody the sample for answering the first research question included 4,913 persons with nursing care needs and 18,753 informal caregivers and for the second research question 1,214 care-dependant persons and 4,061 family caregivers.

2.2. Research model and data analysis

In order to answer research question 2 on the determinants for the adoption and non-adoption of assistive technologies two binary logistic regression analyses using IBM

[2] It also included the view of persons without any experience in nursing care. As this part is not analysed in this study their questionnaire is not presented here.

SPSS 27.0 were performed. Alpha was set to 0.05. The analyses followed the research model (Fig. 1) which clustered groups of potential determinants into demographics, reasons for home care, living / household, nursing status / severity, psychosocial status and type / use of support. We did not refer explicitly to any of the technology acceptance models because it was an exploratory study rather than a hypotheses guided analysis.

Categorial variables were binarized which resulted in 78 predictors derived from 20 variables for the logistic regression of the care-dependent persons and 83 predictors derived from 21 variables for the family caregivers. The additional variable for the caregivers was "employment".

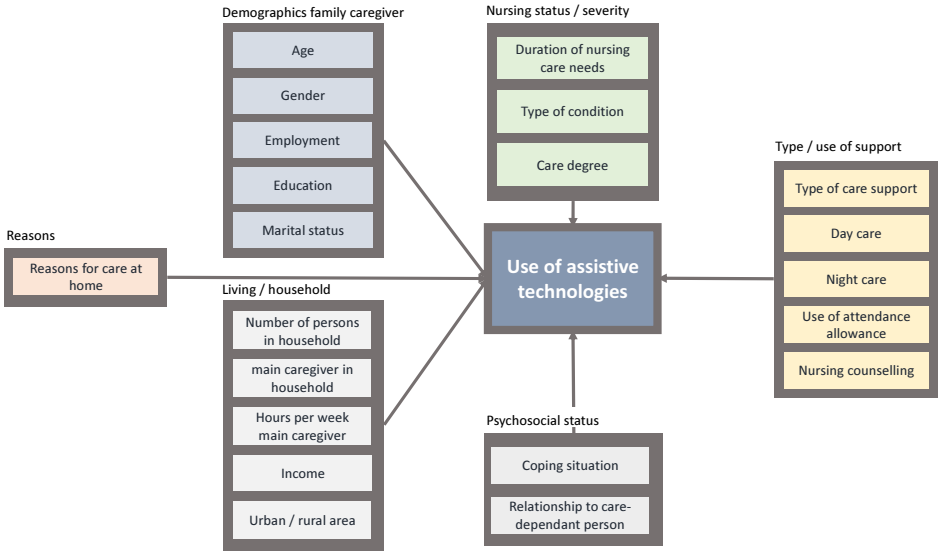

Figure 1. The exploratory research model for family caregivers with 21 variables. The arrows indicate a potential influence on technology use. The model differs only with regard to "employment" (not used), demographics (which relates to the care-dependant person) and "relationship to care dependant person" (to family caregiver) from the model for care-dependant persons.

3. Results

3.1. Adoption rates of different assistive technologies

Roughly one third of the family caregivers and of the care-dependant persons did not use any type of assistive technology at all while all the others use at least one technology (Tab. 2). The technology with the largest number of users was technical (smart) aids followed by emergency call systems. This was true for both groups whereby relatively more family caregivers used these technologies than care-dependant persons. More innovative or sophisticated technologies, e. g. fall detectors, orientations aids, nursing app and telemedicine, were used in less than 5 % of the cases.

3.2. Determinants of adoption and non-adoption of assistive technologies

Out of the 20, respectively 21 potential determinants, nine yielded a significant result in at least one of the two binary logistic regression analyses (Tab. 3). The ones with a positive influence on the adoption of assistive technologies were "duration of the nursing care needs", "care degree" and "type of care support" whereas "number of persons in the household" and "main caregiver in the household" described conditions that were less likely related with the use of assistive technologies. Depending on the type of the condition the results were mixed, e. g. dementia and depression were conditions associated with no usage of assistive technologies while stroke and restricted mobility were positively associated. With regard to demographics variables, only "marital status" reached a significant result: single persons were less likely to use assistive technologies compared to widows. When the psychosocial relationship was described as negative ("nursing care is only reluctantly accepted") the likelihood of using a technology was low in contrast to situations where the relationship was described positively ("our relationship became more intensive"). In a similar way, the reasons of care at home showed mixed findings: a situation where "because other options would have been too expensive" lead to a greater likelihood whereas "because I did not get any help / ambulatory nursing service" to a lower one.

Table 2: Adoption rates for different types of assistive technologies

Assistive Technologies	Care-dependant persons		Family care givers	
multiple answers possible	(N=4,913)	Percent	(N=18,753)	Percent
Emergency call system	1,016	16.5 %	4,034	21.5 %
Technical fall detector (e.g. sensor mat)	37	0.6 %	60	0.3 %
Technical (smart) aid (e.g. special bed, bath lifter, lifter for patient transfers)	1,476	23.9 %	6,330	33.8 %
Nursing app	124	2.0 %	74	0.4 %
Technical monitoring system (e.g. videocamera, safety systems for stove and other household appliances)	185	3.0 %	760	4.1 %
Electronic orientation aid	65	1.1 %	137	0.7 %
Videoconferencing to exchange with others about nursing care	233	3.8 %	219	1.2 %
Telemedicine with family doctor	184	3.0 %	179	1.0 %
I don't use any assistive technology	2,311	37.4 %	5,909	31.5 %
Others	544	8.8 %	1,051	5.6 %

Comparing the perspective of the two groups of persons, "care degree" and "type of service" (availability and use of an ambulatory nursing service) were the only two predictors shared by both groups. They exerted a strong positive influence. Persons receiving support from an ambulatory nursing service for example were more than twice as likely to use technologies than those without. The remaining variables (see all variables in Fig. 1) did not show any significant effect, this included amongst others age, gender, education, employment (in the case of family caregivers), household income or whether the persons lived in a rural compared to an urban area. For both regression analyses the goodness of fit was tested by the Hosmer Lemeshow statistics ($\chi^2 = 7.7$;

df=8; p=0.463 / χ^2 = 9.7; df=8; p=0.288) which was not significant meaning that the fit of the models was good.

4. Discussion

This is the first study to measure the adoption of different assistive technologies by care-dependant persons and family caregivers in the real world in Germany. The findings show that classical technologies, namely emergency call systems and technical (smart) aids are the ones with the by far greatest adoption rate in both groups. Summarised they represent 40.4 % of the answers of the care-dependant persons and 55.3 % of those of the family caregivers. Innovative and more sophisticated technologies, such as fall detectors and orientation aids, are used altogether by only less than one quarter. Taking into account the general positive attitude towards these technologies [4] and taking into account the great many research activities in the field of ambient assisted living this is disappointing. Either the technologies seem to be not mature enough or there is obviously not enough awareness about their advantages. Collectively, it looks as if the diffusion process is just ongoing having reached the innovators and early adopters. Inspecting the individual adoption rates of the technologies, most of them are used just by innovators [12]. As adoption still is in its infancy, it seems interesting not only to investigate use and no use but respect the phases prior to use: from evaluating and acknowledging the need to incorporating the assistive technology into daily life [13].

The two regression analyses shed some light into what circumstances and characteristics can act as determinants of the adoption either as facilitators or inhibitors. The most salient finding is that the higher the care degree is the more likely is the use of assistive technologies. This holds true from both perspectives, the care-dependant person and the caregiver. What is more surprising is the facilitating role of ambulant nursing services. Obviously, they can act as mediators, enablers and counsellors again from both viewpoints - as was demanded and anticipated [14]. Also, other support services function in a similar role, in particular from the perspective of the caregivers. There seems to be no evidence that assistive technologies can replace nurses or other persons providing support. On the contrary and in line with the name “assistive technologies” they assist people. An improved relationship between caregiver and care-dependant person was a positive indicator for the use of technology, whereas accepting care only reluctantly a negative one. However, if there are more persons in the household and if the main caregiver lives in this household there is seemingly no need for further technological aids.

The condition of the care-dependant person may influence the use. Here the findings are more ambiguous but hint at the fact that dementia and depression do not facilitate the employment of technologies. This stands in contrast to the multitude of studies on dementia and technical assistance but is corroborated by a study from Sweden where - apart from technologies for remembering - dementia was associated with a lower likelihood of using these technologies [15]. Persons suffering from conditions with concrete needs such as “restricted mobility”, “stroke” and “incontinence” were more likely to seek technical assistance. Also, the reasons for care had an influence. It is noteworthy that many of the classical determinants, such as age, gender, income and education, did not play any role whether technology is used nor not.

There are some limitations going along with this study. The sample of the family caregivers is biased towards higher care degrees of their care-dependant family members than the German population. Furthermore, a self-selection bias cannot be ruled out. This

part of the study did not reveal the reasons why the respondents used or did not use assistive technologies and the regression analyses did not distinguish between classical assistive technologies (emergency call system and technical aids such as lifters) and innovative technologies (e. g. nursing app, telemedicine). It also did not distinguish by whom the technology was used in the case of family care givers.

Table 3: Results of binary logistic regressions for care-dependant persons and family care givers. Results are shown where variable was significant in at least one of the two groups. Legend: n. s. not significant

		care-dependant persons				**family caregivers**			
group of variables of research model	**predictors**	odds ratio	95% CI lower limit	95% CI upper limit	p	odds ratio	95% CI lower limit	95% CI upper limit	p
nursing status / severity	duration of nursing care needs	**1.026**	1.004	1.050	0.022				n.s.
nursing status / severity	care degree	**1.740**	1.420	2.133	< 0.001	**1.504**	1.374	1.646	< 0.001
nursing status / severity	condition: dementia				n.s.	**0.711**	0.593	0.851	< 0.001
nursing status / severity	condition: incontinence				n.s.	**1.298**	1.101	1.530	0.002
nursing status / severity	condition: restricted mobility				n.s.	**1.423**	1.192	1.698	< 0.001
nursing status / severity	condition: depression	**0.686**	0.508	0.924	0.013				n.s.
nursing status / severity	condition: stroke				n.s.	**1.278**	1.063	1.535	0.009
living / household	number of persons in household				n.s.	**0.970**	0.944	0.998	0.034
living / household	main care giver in household				n.s.	**0.707**	0.583	0.857	< 0.001
type / use of support	type of support: ambulatory nursing service	**2.129**	1.463	3.097	< 0.001	**2.163**	1.820	2.569	< 0.001
type / use of support	type of support: support service	**3.731**	1.473	9.448	0.005				n.s.
type / use of support	type of support: short term care				n.s.	**1.306**	1.014	1.682	0.037
type / use of support	type of support: 24 hour care				n.s.	**1.604**	1.081	2.381	0.019
demographics	marital status: single vs. widow	**0.421**	0.181	0.980	0.045				n.s.
psychosocial status	relationship: nursing care is only reluctantly accepted				n.s.	**0.766**	0.600	0.978	0.032
psychosocial status	relationship: our relationship became more intensive				n.s.	**1.225**	1.004	1.495	0.046
reason for care at home	reason: because I did not get any help / any ambulatory nursing service				n.s.	**0.650**	0.446	0.948	0.025
reason for care at home	reason: because other options (e.g. nursing home) would have been too expensive	**1.553**	1.082	2.229	0.017				n.s.

5. Conclusion

It can be concluded that innovative and sophisticated types of assistive technologies are still rather scarcely used for home care arrangements in the real world despite large research efforts in the last twenty years. As ambulatory nursing services are obviously a key and enabler to technology use, the questions arise about (i) what role they can play to further identify needs and to raise the awareness for these technologies as well as (ii) what competencies they need to fulfil these tasks. These questions are of particular interest for care-dependant persons suffering from dementia and their family care givers.

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Declarations

Ethics: A positive vote was obtained in February 2021 from the Ethics Commission of Hochschule Osnabrück (final VoteID: HSOS/2021/1/2).

Contributions of the authors: AS initiated and designed the study; IY, MP and UH analysed the data, UH and AS drafted the manuscript with IY and MP joining them.

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