Research on Aging
2020, Vol. 42(5-6) 163–173

DOI: 10.1177/0164027520911286
journals.sagepub.com/home/roa
SAGE

Assistive Technology and Mobile ICT Usage Among Oldest-Old Cohorts: Comparison of the Oldest-Old in Private Homes and in Long-Term Care Facilities

Anna Schlomann[1,2], Alexander Seifert[3,4], Susanne Zank[5] and Christian Rietz[2]

Abstract

This study examines technology adoption among oldest-old cohorts (80+) in private homes and long-term care facilities and analyzes relationships between individual characteristics, the living environment, and different kinds of assistive technologies (AT) and information and communication technologies (ICT). The data analysis is based on a representative survey of the oldest-old group's quality of life and well-being in North Rhine-Westphalia, Germany ($N = 1{,}863$; age range: 80–103; 12.7% long-term care). Descriptive and multiple binary logistic regression analyses were conducted. Fewer than 3% of people in long-term care used internet-connected ICT devices. AT and ICT device adoption is associated with the living environment and individual characteristics (e.g., functional health, chronological age, education, and technology interest), and different patterns of ICT and AT use can be observed. These results indicate that individual characteristics and the living environment are both decisive in the use of technology among the oldest-old group.

Keywords

fourth age, digitalization, community-dwelling, technology

Innovations such as assistive technologies (AT) and information and communication technologies (ICT) have great potential to enhance independence for older adults and may be related to health, cognitive functioning, independence maintenance, and social inclusion in advanced age (e.g., Czaja et al., 2018; Forsman & Nordmyr, 2017; Kamin & Lang, 2018; Schulz et al., 2015; Sims et al., 2017).

While technology use among the young-old (65–79 years) group has developed as a major theme in gerontology, the situation differs among those of advanced age (80+). Little is known about the everyday use of technology in the oldest-old cohorts nor about individual differences between users and nonusers of different kinds of technologies. Members of the oldest-old group are often underrepresented in large-scale survey research, and researchers face unique challenges in studying this group (Davies et al., 2010; Hunsaker & Hargittai, 2018). Available public statistics often incorrectly estimate the percentages of older technology users because the statistics are mostly based on samples of older adults in private homes and do not consider older adults who live in long-term care settings (Cotten, 2017; Moyle et al., 2018; Seifert et al., 2017). Furthermore, telephone surveys are usually applied to study technology use; such surveys often systematically exclude people in long-term care and discriminate against those with hearing problems, which can then limit their willingness to participate (Kelfve et al., 2013).

This study addresses these gaps in research by analyzing the use of technologies among the very old age-group based on a representative survey study in which personal interviews were conducted among oldest-old cohorts (80+) in private homes and long-term care facilities. Analyzing the level of technology adoption and understanding the factors that influence adoption in very old age together allow for a better understanding of the role of technologies during very old age.

Relevance of Technologies in Very Old Age

Our understanding of technologies includes all technologies that may support the oldest-old in everyday life. We broadly distinguish between two types of technologies: AT and ICT.

[1] Network Aging Research, Heidelberg University, Germany
[2] Mixed Methods Research, Heidelberg University of Education, Germany
[3] Division of Sociology, Social Policy and Social Work, University of Fribourg, Switzerland
[4] Center of Competence for Gerontology, University of Zurich, Switzerland
[5] Department of Special Education and Rehabilitation Science, Chair of Rehabilitative Gerontology, University of Cologne, Germany

Corresponding Author:
Anna Schlomann, Network Aging Research, Heidelberg University, Bergheimer Straße 20, 69115 Heidelberg, Germany.
Email: schlomann@nar.uni-heidelberg.de

AT are an important category of technologies for those in advanced age (Garçon et al., 2016). The International Organization for Standardization (ISO) has defined AT in the norm ISO (2016) 9999 as

> any product (including devices, equipment, instruments and software), especially produced or generally available, used by or for persons with disability for participation, to protect, support, train, measure or substitute body functions/structures and activities, or to prevent impairments, activity limitations or participation restrictions.

Yusif et al. (2016) specify that "[such technologies may] include mobility aids, vision and hearing aids, furniture or daily living aids, gadgets or small aids, and adaptation to accommodation" (p. 113). AT can enhance people's independence and compensate for age-related health conditions and losses (Schulz et al., 2015). Harrington et al. (2015) review of the use of AT among older adults reported that 14%–18% of older adults in private homes used any kind of AT, while this use increased with age (Harrington et al., 2015). Although robotics is another relevant type of AT, in our article, we focus on AT that have already been implemented in older adults' everyday settings (Peine & Neven, 2019) including hearing aids, wheelchairs, and emergency call systems.

The second category of technologies we examine in the study consists of ICT devices, which include mobile phones, computers, smartphones, and tablets. These devices are designed to connect with others, and they allow for social interaction over long distances (e.g., text messages, video chats, and social networking sites). ICT may also be used for instrumental purposes such as for keeping up-to-date on the latest news or making purchases online. Many older adults lag behind in their ownership of modern technology compared to the general population, however (Hunsaker & Hargittai, 2018; Mitzner et al., 2018; Pew Research Center, 2018). A digital divide still exists on different levels including aspects of limited access to technology (first-level divide) and ICT skills (second-level divide) among older cohorts (Francis et al., 2019).

Further differences exist between the young-old and the oldest-old groups. Using European (EU and non-EU) data, König et al. (2018) showed that fewer than 10% of those aged 80 and older accessed the internet, while 48% of Europeans aged 65–69 accessed the internet. Seifert et al. (2017) reported that 14% of residents in long-term care institutions in Switzerland accessed the internet. For older people who live in long-term care facilities, ICT could to some extent play an instrumental role in interconnectedness and social stimulation; such technologies can also be seen as a way to connect residents' world—which can be isolated—with the outside world (Bobillier Chaumon et al., 2014).

Factors of Technology Adoption in Private Homes Versus Long-Term Care Facilities

For the oldest-old group to be able to successfully use technologies, older adults' decisions about technology adoption and acceptance must first be understood. Older adults may use (or not use) technologies for a number of reasons. One relevant theoretical model for describing technology adoption is the technology acceptance model (TAM; Davis, 1989). The model's hypothesis is that a positive attitude toward using technology, influenced by perceived usefulness and perceived ease of use, leads to the intention to use a given technology. The TAM has become one of the most widespread models for analyzing technology adoption decisions (King & He, 2006; Marangunić & Granić, 2015). Conceptual revisions of the TAM have led to the inclusion of individual characteristics such as age, gender, and prior experience to explain technology adoption and have tailored the model to older adults (Francis et al., 2019). Chen and Chan (2014) showed that certain ability factors (such as functional and cognitive abilities) had an effect on technology use in older adults.

Various empirical studies and reviews (e.g., Czaja et al., 2006; Harrington et al., 2015; Hunsaker & Hargittai, 2018; König et al., 2018) have demonstrated the effect of individual characteristics such as age, gender, and education on technology adoption in old age. Other research has shown that instrumental activities of daily living impairments represent an important hurdle for ICT use among older adults in independent and assisted living communities (Cotten et al., 2016; Rikard et al., 2018). As Czaja and colleagues (2006) point out, also the breadth of technology experiences is predicted by demographic variables, attitudes, and ability factors. Barriers to technology adoption in advanced age include insufficient training, cognitive decline, and a lack of access and skills (Berkowsky et al., 2018; Rikard et al., 2018). Oldest-old people in long-term care facilities represent a special group. They are more likely to have physical and cognitive impairments, higher risk of chronic diseases, and more care needs compared to older adults who live in private homes. Older adults in institutional environments thus may be less likely than younger adults to use new technologies in ways that go beyond compensation for losses (Seifert et al., 2017).

Beyond these differences on the individual level, also environmental factors are important when comparing the factors of technology adoption in private homes and institutional settings. On a conceptual level, this is embedded into the assumptions of environmental gerontology (Wahl et al., 2012). Environment-related factors can include social factors (e.g., children, professional caregivers, and friends can positively or negatively influence the acceptance of technology) and technical–spatial environment (e.g., existing ICT infrastructure).

New technologies can be an enrichment of the environment and at the same time represent new requirements for the (aging) individual. In the context of the environmental press-competence model (Lawton, 1982), we would expect that residents in institutional settings (e.g., long-term care), predominantly very old and health-impaired individuals as well as being "framed" by a setting likely exerting high control on daily life, are strongly influenced by the existing technology infrastructures and other regulations and organizational features of their environment. Residing in long-term care

compared to living in a private home means living in an age-segregated setting in an institution with potential elements of "totality" (Goffman, 1961). This situation also implies less decision involvement in the implementation of new technologies in the institution. Today, care facilities often do not offer the same ICT infrastructure that is available in private homes (Moyle et al., 2018). Therefore, we would expect effects of the living environment on technology adoption beyond the effects of individual differences and acceptance.

Research Objectives

The use of technologies among oldest-old cohorts is a poorly understood phenomenon. One key drawback is that survey research on technology adoption often fails to consider those who live in long-term care (Cotten, 2017; Hunsaker & Hargittai, 2018). But there are good reasons to assume differences in technology adoption between those in private homes and those in long-term care facilities. We would expect higher adoption rates of AT and lower adoption rates of ICT among those in long-term care compared to those in private homes. Some possible differences could be due to individual characteristics such as functional health, care needs, age, gender, education, and interest in technology, while others may be caused by characteristics of the living environment, such as technology infrastructures. We furthermore analyze the patterns of use for ICT and AT (e.g., number of devices, combinations of different devices) because this provides further insights into the use of technologies and attitudes. We argue that those who use a combination of different ICT devices are generally more open toward new technologies and have integrated modern technologies into their everyday life. For AT, we would expect the older and more frail individuals to have a higher need of different AT. Individuals in long-term care may use different ICT and AT than individuals in private homes due to technology infrastructures.

To better understand technology use and the factors of technology adoption among the very old, this research article has two objectives to: (1) describe the adoption of different types of technologies (AT and ICT) among the very old in private homes and long-term care and (2) explore the associations between technology adoption, individual characteristics, and the environment.

Research Design

Data and Study Sample

This study's analyses are based on data from Wagner et al. (2018) NRW80+ project, which was the first representative statewide survey study on quality of life and subjective well-being of the oldest-old (80+). The NRW80+ was performed in the German federal state of North Rhine-Westphalia (NRW), which is the federal state with the largest population in Germany. NRW is often described as a small Germany: With its large industry, structurally weak regions, and medium-sized wealth, the federal state reflects the whole of Germany. Multistage sampling was applied with a random sample of people aged 80 years and older in private homes and institutional settings. There were no exclusion criteria for the study beyond the definition of the targeted population as aged 80 years or older at the time of study. The random register sample includes individuals residing in private homes and long-term care facilities. Trained interviewers assessed potential respondents' capacity for informed consent and ability to conduct the approximately 90-min standardized interview. When a target person was willing to participate in the study, but cognitively or physically unable to answer to the interview, the interview was conducted with a close proxy informant. Consent of the target person was obtained for this purpose. The group of possible proxy persons was not restricted (e.g., to relatives). However, the proxy informant should be able to provide sufficient information about the target person. The proxy interviews make a significant contribution to the representation of persons with more pronounced health impairments in the targeted population. A screening of age-adequate cognitive functioning and mild cognitive impairment (Kalbe et al., 2014) was applied in the interviews with the target persons. More pronounced levels of cognitive impairment in the group of very old persons represented by proxy interviews were reported by proxy informants using the Global Deterioration Scale (Reisberg et al., 1982). A total of 1,863 computer-assisted personal interviews were conducted in the NRW80+ study, including 165 interviews with proxy informants.

The mean age within the sample was 85.6 years (standard deviation [*SD*] = 4.20), with an age range from 80 to 103 years. In total, $n = 1{,}187$ (63.7%) of the NRW80+ subjects were female. Within the sample, $n = 1{,}623$ (87.3%) lived in private homes and $n = 236$ (12.7%) lived in long-term care ($n = 4$ cases were excluded because they did not answer the question on the type of residence); $n = 603$ (33.2%) had a care level of some kind. The mean age among individuals in private homes was 85.16 years ($SD = 3.81$), and the mean age among individuals in long-term care was 88.94 years ($SD = 5.13$). Of those who had a care level, $n = 181$ (30.2%) lived in institutional care settings. The level of functional health (on a scale ranging from 0 to 2) was lower among individuals in long-term care ($M = 0.47$, $SD = 0.56$) compared to individuals in private homes ($M = 1.53$, $SD = 0.59$). This study was approved by the ethics committee of the Medical Faculty of the University of Cologne (No. 17-169). All participants gave their informed consent to participate.

Measures

Technology use. The NRW80+ study (Wagner et al., 2018) included limited questions on technology use. All participants were asked whether they had used the following AT and ICT devices (yes/no) during the last 12 months: hearing aid, wheelchair, emergency call system (i.e., home system within the own household or room to call for help), PC/laptop, mobile phone, smartphone, tablet. Based on this information, in this study, we have distinguished between technology users and nonusers in the following way:

- *AT versus no AT*—This binary variable distinguishes between those who use any assistive device (hearing aids, wheelchairs, and/or emergency call systems) and those who do not.
- *ICT versus no ICT*—This binary variable distinguishes between those who use any ICT device (mobile phones, PC/laptops, smartphones, and/or tablets) and those who do not.

The two groups are not exclusive: People can belong to neither of them, one of them, or both. To analyze the patterns of ICT and AT use, we computed new variables that indicate the sum of devices for which participants reported use (range ICT: 0–4 devices, range AT: 0–3 devices).

Living environment. Environment-related factors such as the living environment may influence the use of technologies (e.g., Peek et al., 2014; Seifert et al., 2017). People who live in private homes and those who live in long-term care cannot be easily compared, however, due to the different nursing and support requirements. We distinguish between three groups to isolate individual differences and differences in the living environment: (1) those who live in private homes and do not receive care, (2) those who live in private homes and receive care (e.g., ambulatory care, day care, and/or private care by relatives/friends), and (3) those who live in long-term care facilities. In this study, the group of individuals who live in long-term care includes people who permanently live in institutional settings like nursing homes and receive assistance with domestic tasks (e.g., preparing meals), personal care tasks (e.g., dressing, washing), and other kinds of nursing care. Individuals who live in long-term care were chosen as reference group in the multivariate analyses because one of our main study focuses is on a comparison of the living environments (i.e., private home vs. long-term care).

Social environment. The social context may also be related to technology use. We included several indicators of social inclusion into the analyses. We included the number of children and (great) grandchildren (continuous in absolute numbers), the frequency of contact with other people (i.e., family and friends; 5-point scale, *never*, *seldom*, *sometimes*, *often*, and *very often*), and the participation in social activities outside the family involving drinking coffee and going out (6-point scale, *never*, *once a year*, *several times a year*, *monthly*, *weekly*, and *daily*).

Functional health. Conceptual work based on the TAM has shown that functional abilities may have an effect on technology adoption in old age (Chen & Chan, 2011, 2014). In our analysis, we apply a measure of people's functional health status that comprises seven IADLs: using a telephone, getting somewhere, buying groceries or clothing, preparing one's own meals, doing housework, taking medication, and arranging financial matters. For every activity, people were asked whether they could perform the activity "only with help" (assigned a value of 0), "with a little help" (1), or "without help" (2). Based on the subjects' answers, we computed a mean score of all 7 items ranging from 0 to 2. We then used this variable as a metric variable in the analyses.

Technology interest. People's attitudes toward technology are relevant for technology use (e.g., Czaja et al., 2006). We use people's interest in technology as a measure for technology attitude using 1 item, based on the work of Seifert and Schelling (2018), in which subjects were asked, "How much are you interested in new technologies?" The subjects answered on a 5-point Likert-scale from *not interested at all* (0) to *very interested* (4). We used this variable as a metric variable in a mean-centered format.

Demographic variables. Other studies (e.g., König et al., 2018) and current reviews (Hunsaker & Hargittai, 2018) have shown that sociodemographic characteristics influence the use of new technologies in old age. We thus included demographic variables as control variables in our analyses. These variables included the person's age (continuous in years and mean centered), gender (ref. female), and level of education (low [reference], middle, and high) according to the classification of education in the German Aging Survey, which is based on the International Standard Classification of Education (ISCED).

Statistical Analyses

SPSS Version 25 (IBM Statistics, NY, USA) was used for statistical analyses. Any missing data were excluded in a listwise manner. The data were weighted for analyses using design and poststratification weights. In this approach, the age and gender distribution of the sample is adjusted (in this case to the target population of the oldest-old [80+] in NRW), which then allows for extrapolating the survey results to the state population. Descriptive uni- and bivariate analyses and multiple binary logistic regression analyses were applied. In the first step, we described the use of technology in the three groups of people: private home without care, private home with care, and long-term care facilities. Using bivariate significance tests (*t*-testing for independent samples and χ^2 tests), we analyzed the bivariate relationships between technology use, individual characteristics, the living environment, and the social environment. We then performed binary logistic regression analyses to explore these relationships in more detail. The first analysis distinguished between users and nonusers of ICT devices, while the second analysis distinguished between users and nonusers of AT. Both models are controlled for whether the interview was conducted with a proxy informant. An additional analysis examined the patterns of ICT and AT use. We applied descriptive analyses based on the sum of devices for which participants reported use and the single items on technology use.

Table 1. Use of Technology in Private Homes Versus Long-Term Care Facilities.

Devices	Total	Private Home: No Care Received	Private Home: Care Received	Long-Term Care Facility	χ^2
ICT	**57.3**	**72.7**	**38.6**	**16.5**	**337.39 (2); $p < .001$**
Mobile phone	49.5	64.9	32.9	14.7	251.77 (2); $p < .001$
Computer	19.0	26.2	9.2	2.1	110.98 (2); $p < .001$
Smartphone	11.9	16.5	5.4	1.7	65.112 (2); $p < .001$
Tablet	7.6	10.4	3.8	0.4	39.99 (2); $p < .001$
Assistive technologies	**51.3**	**39.2**	**65.2**	**84.7**	**209.13 (2); $p < .001$**
Hearing aid	30.4	29.1	34.3	29.4	4.29 (2); $p = .117$
Emergency call system	24.1	13.4	32.6	61.4	267.29 (2); $p < .001$
Wheelchair	14.4	1.9	24.9	56.5	529.33 (2); $p < .001$

Note. The percentages of users of the respective technologies are shown in the columns. User groups (ICT and assistive technologies) are not exclusive: People can belong to neither, one, or both groups. ICT = information and communication technologies.
Bold values represent the main categories of the devices.

Results

Frequency of Technology Use in Private Homes Versus Long-Term Care Facilities

In the first step, we described the use of technologies by people in private homes who received or did not receive care compared to those in long-term care facilities (see Table 1). In total, 57.3% of all participants used any ICT, and 51.3% used any AT. With the exception of hearing aids, the use of technologies differed significantly between the groups. Almost no one in long-term care used web-connected ICT devices such as smartphones, tablets, and computers, and they used mobile phones only to a limited extent (14.7%). AT were used by a larger share of people; for example, 56.5% of those in long-term care used a wheelchair, and 61.4% used an emergency call system. Nevertheless, also a share of people within private households used AT; for example, 32.6% of participants living in private homes and receiving care are using an emergency call system.

Among older adults in private homes who did not receive care, mobile phones were the most commonly used technological device (64.9%), followed by hearing aids (29.1%). In contrast, among those in private homes who received care, only 9.2% used a computer, and 5.4% used a smartphone. In this group, hearing aids (34.3%) were the most often used technology, followed by mobile phones (32.9%) and emergency call systems (32.6%). We identified a negative correlation between the use of ICT and the use of AT ($r = -.16$, $p < .001$).

Use of Technologies by Individual Characteristics and the Social Context

Second, we looked at bivariate relationships between individual characteristics and the use of AT and ICT as well as between the social context and the use of AT and ICT (see Table 2). Bivariate analyses showed that the use of ICT and AT differed between males and females. ICT users had higher levels of functional health, reported more interest in technology, and were younger than nonusers of ICT. Users of AT were observed to be older and to have poorer functional health than nonusers. Interest in technology was lower in the group of users of AT. While ICT use varied between people with different educational levels, no differences in educational levels were observed for users and nonusers of AT. Only few significant relationships were observed for the social context. Having (great) grandchildren was related to the use of ICT: Individuals who did not use ICT had more (great) grandchildren on average compared to ICT users. Spending time with other people more frequently was negatively related to the use of AT and positively related to the use of ICT (see Table 2).

Multivariate Analyses

To explore these bivariate findings in more detail, we then used binary logistic regression analyses. The first model distinguished between users and nonusers of ICT devices (ICT = 1; no ICT = 0). The overall model was significant ($\chi^2[13] = 682.00$; $p < .001$; Nagelkerke $R^2 = .45$; see Table 3). The likelihood of the model at predicting group membership was 76.7%. Compared to people who lived in long-term care, those in private homes (*no care*: odds ratio [*OR*] = 1.91, $p = .020$; *care received at home*: $OR = 1.75$, $p = .028$) were more likely to use ICT. Younger age ($OR = .90$, $p < .001$) and higher education levels (*medium level*: $OR = 1.83$, $p < .001$; *high level*: 3.16, $p < .001$) were associated with a higher probability to use ICT. Having better functional health ($OR = 2.15$, $p < .001$) and more children ($OR = 1.14$, $p = .047$) also added to the chance of using ICT. No significant effects of the other social factors nor of gender ($p = .837$) were observed, but interest in technology ($OR = 1.92$, $p < .001$) was associated to a higher probability to use ICT.

The second model, which distinguished between users and nonusers of AT (AT = 1; no AT = 0), was significant overall, $\chi^2(13) = 322.29$; $p < .001$, with a Nagelkerke $R^2 = .23$. The overall likelihood of the model at predicting group membership was 68.5%. Compared to people in long-term care, those in private homes had a lower likelihood of using AT, regardless of whether they received care ($OR = .36$, $p < .001$) or not ($OR = .28$, $p < .001$). Having more children ($OR = 1.14$,

Table 2. Use of Technologies by Individual Characteristics and the Social Context.

Individual Characteristics and Social Context		ICT			Assistive Technologies		
		Users	Nonusers	t/χ^2	Users	Nonusers	t/χ^2
Functional health	Mean (*SD*)	1.69 (0.46)	1.01 (0.74)	$p < .001$	1.16 (0.73)	1.64 (0.54)	$p < .001$
Age	Mean (*SD*)	84.5 (3.50)	87.2 (4.54)	$p < .001$	86.8 (4.50)	84.4 (3.45)	$p < .001$
Interest in technology	Mean (*SD*)	2.87 (1.38)	1.57 (0.92)	$p < .001$	2.17 (1.33)	2.47 (1.40)	$p < .001$
Gender	Female (%)	49.2	50.8	$p < .001$	54.5	45.5	$p < .001$
	Male (%)	71.1	28.9		45.9	54.1	
Education	Low (%)	37.7	62.3	$p < .001$	55.6	44.4	$p = .070$
	Medium (%)	61.2	38.8		50.2	49.8	
	High (%)	80.1	19.9		48.2	51.8	
Number of children	Mean (*SD*)	2.07 (1.36)	2.10 (1.54)	$p = .681$	2.11 (1.46)	2.04 (1.42)	$p = .260$
Number of grandchildren/great-grandchildren	Mean (*SD*)	3.32 (3.73)	4.33 (5.95)	$p < .001$	3.96 (5.24)	3.53 (4.34)	$p = .057$
Frequency: time with other people	Mean (*SD*)	2.65 (0.91)	2.49 (0.99)	$p < .001$	2.54 (0.98)	2.62 (0.92)	$p = .047$
Frequency: participation in social activities, for example, drinking coffee	Mean (*SD*)	1.72 (2.46)	1.45 (3.61)	$p = .068$	1.66 (3.87)	1.72 (4.42)	$p = .725$

Note. The rows are shown in percentages; *t* testing was applied for independent samples for functional health, age, interest in technology, number of children, number of grandchildren/great-grandchildren, frequency: time with other people, frequency: participation in social activities, for example, drinking coffee; χ^2 testing was applied for gender and education. User groups (ICT and assistive technologies) are not exclusive: People can belong to neither, one, or both groups. ICT = information and communication technologies.

Table 3. Multiple Binary Logistic Regression Analyses to Predict Use of Technology.

Independent Variables	M1: ICT			M2: Assistive Technology		
	b (*SE*)	*OR*	*p*	*b* (*SE*)	*OR*	*p*
Private home: no care received (ref. long-term care)	0.65 (.28)	1.91	.020	−1.27 (.28)	0.28	<.001
Private home: care received (ref. long-term care)	0.56 (.26)	1.75	.028	−1.02 (.25)	0.36	<.001
Number of children	0.13 (.06)	1.14	.047	0.13 (.06)	1.14	.017
Number of (great) grandchildren	−0.03 (.02)	0.97	.144	−0.03 (.02)	1.00	.857
Time with other people	0.10 (.07)	1.11	.131	−0.03 (.06)	0.97	.587
Social activities	0.01 (.02)	1.01	.623	0.06 (.03)	1.07	.056
Functional health (IADLs)	0.76 (.15)	2.15	<.001	−0.96 (.15)	0.38	<.001
Age	−0.11 (.02)	0.90	<.001	0.11 (.02)	1.11	<.001
Gender: male	−0.03 (.15)	0.97	.837	−0.20 (.13)	0.81	.122
Education level: medium (ref. low)	0.60 (.15)	1.83	<.001	0.20 (.14)	1.22	.140
Education level: high (ref. low)	1.15 (.22)	3.16	<.001	0.36 (.18)	1.43	.046
Interest in technology	0.65 (.06)	1.92	<.001	0.07 (.05)	1.08	.143
Proxy (ref. no proxy informant)	−0.58 (.32)	0.56	.070	−1.15 (.33)	9.64	<.001
Constant	−2.10 (.34)	0.12	<.001	2.27 (.33)	9.64	<.001
Model fit	$\chi^2 = 682.00$ (13); $p < .001$; Nagelkerke R^2: .45			$\chi^2 = 322.29$ (13); $p < .001$; Nagelkerke R^2: .23		

Note. $n = 1{,}675$. Age and interest in technology are mean centered. Both models are controlled for whether the interview was conducted with a proxy informant. *b* = logits; *SE* = standard error; *OR* = odds ratio; IADLs = instrumental activities of daily living; ICT = information and communication technologies; ref. = reference.

$p = .017$) and a high level of education ($OR = 1.43$, $p = .046$) were associated with a higher probability to use assistive devices. Younger age ($OR = 1.11$, $p < .001$) and better functional health ($OR = .38$, $p < .001$) were associated with a lower probability to use assistive devices. No significant effects were found in the number of (great) grandchildren ($p = .857$), the frequency of time with other people ($p = .587$), the frequency of participation in social activities ($p = .056$), technology interest ($p = .143$), gender ($p = .122$), or a medium level of education ($p = .140$; see Table 3).

Patterns of Technology Use

An additional descriptive analysis explored the patterns of ICT and AT use. Among ICT users, 65.1% reported to use only one ICT device, 26.5% reported to use two ICT devices, and 8.5% reported to use three ICT devices. No one reported to use all four ICT devices. Among users of mobile phones, 74.5% did not use another ICT device, while among users of tablets, only 4.3% did not use another ICT device, and 63.8% used two other ICT devices.

Table 4. Patterns of Technology Use.

Patterns of Use	One Device Used	Two Devices Used	Three Devices Used
Patterns of ICT use	**65.1**	**26.5**	**8.5**
Private home: no care received	61.8	28.8	9.4
Private home: care received	76.9	17.3	5.8
Long-term care facility	87.2	12.8	0
Mobile phones users	74.5	20.2	5.3
Computer users	5.4	69.3	25.4
Smartphone users	29.6	49.3	21.1
Tablet users	4.3	31.9	63.8
Patterns of AT use	**71.1**	**24.0**	**4.9**
Private home: no care received	87.3	12.2	0.4
Private home: care received	65.4	28.4	6.2
Long-term care facility	41.0	45.5	13.5
Hearing aid users	66.5	25.1	8.3
Emergency call system users	45.6	44.0	10.4
Wheelchair users	37.2	45.1	17.7

Note. Analyses are based on ICT/AT users only. No one reported to use all four ICT devices. The percentages of users of the respective technologies are shown in the rows. User groups (ICT and AT) are not exclusive: People can belong to neither, one, or both groups. ICT = information and communication technologies; AT = assistive technologies.
Bold values represent the main categories of the devices.

Among AT users, 71.1% reported to use only one AT, 24.0% reported to use two AT, and 4.9% reported to use all three AT. Among users of hearing aids, 66.5% did not use another AT. Among users of emergency call systems and among users of a wheelchair, more than half of the users used at least one additional AT. Different patterns were observed for individuals in private homes and in long-term care: The use of more than one AT was more common in long-term care and the use of more than one ICT was more common in private homes (see Table 4).

Discussion

Our research has examined technology adoption of different types of technologies (AT and ICT) among the oldest-old group; we have explored associations between technology use and individual characteristics. One distinctive element of our study is that the findings are based on a representative sample of people aged 80 years and older who live in private homes and in long-term care settings.

Our study results have shown that the oldest-old group generally uses a broad range of technologies. More than half the study subjects used at least one ICT device, and more than half used any AT device. Among older adults in private homes who did not receive care, mobile phones were the most commonly used technological device. The recent Initiative D21 (2019) project also found that mobile phones are the most often used technical device of all devices among older adults in Germany, while smartphones are the most often used technology among the general German population. From the perspective of research on technology generations (e.g., Sackmann & Winkler, 2013), this finding implies that technologies are an integral part of older adults' everyday lives today, but they use different technologies than younger generations.

Our findings also fit the conclusion that an age-related digital divide still exists (Mitzner et al., 2018; Francis et al., 2019). The use of AT in our study was more frequent than reported in a review of younger-old cohorts (Harrington et al., 2015), thus indicating more of a need for assistance through technologies with advancing age. The usage rates of modern ICT devices were lower in our study when compared to those of the general population (e.g., Pew Research Center, 2018) as well as among younger-old cohorts (e.g., König et al., 2018). This finding was supported by the analysis of the patterns of technology use. Among ICT users, the majority reported to use only one device, which may indicate that the oldest-old have not yet integrated modern internet-connected technologies into their everyday life to a large extent. Some people among the oldest-old cohort use web-connected ICT devices, but they show marked differences between subgroups. Among people who live in private homes and do not receive care, our study found that every sixth person used a smartphone, while contact with technology in institutional environments was mostly reduced to AT. Another reason for these differences beyond individual differences might be different technology infrastructures in private homes and institutional settings (Moyle et al., 2018; Seifert et al., 2017). These infrastructures can only be changed to a small extent by the individuals living in long-term care. AT were more often used in long-term care and among those who received care at home. Furthermore, the use of more than one AT was more common in long-term care than in private homes. In addition to the higher frailty of these persons, the advice from the nursing care consultants might be a reason for a larger spread of AT. Nursing care consultants determine the individual need for help and provide advice on the range of services available, including assistive devices like walkers, hearing aids, and wheelchairs (German Federal Ministry of Health, 2019). Especially in nursing homes, there is a greater awareness for these services.

This finding is in line with previous research (Yusif et al., 2016), although how and to what extent AT can foster independence in the context of long-term care is an open question. Our findings also suggest that ICT's potentials for interconnectedness among older adults—especially in long-term care facilities—have yet to be realized. Wahl and Gerstorf's (2018) question of "whether and how technology serves as a window to the world during times when functional limitations become more frequent and severe" (p. 16) must be answered negatively vis-à-vis our findings of less ICT usage among those in long-term care.

Significant gender differences were only identified in our bivariate analyses but not in the multivariate models. This finding fits Harrington et al.'s (2015) interpretation in their review of AT who also found inconclusive findings on the relationship between the use of AT and gender. In the context of ICT use, this is a new finding since men tend to show higher usage rates of technologies in old age (e.g., König et al., 2018). This result might indicate that the oldest-old cohort represents a special group in terms of ICT use among older adults. Functional abilities and limitations might be more relevant for ICT use in this group than any gender differences caused by the different technological biographies of men and women. Although social factors have been shown to affect technology use in prior studies on technology use, we did not identify large effects of these factors, while the living environment seemed to be more important. These findings and assumptions should be evaluated and tested in further studies.

In conclusion, we have shown that the living environment has a distinct effect on technology adoption beyond individual characteristics such as age, functional health, and care needs. At the same time, these individual characteristics also showed a significant effect on technology adoption. These findings lead us to conclude that both factors—individual and environmental—are important for the adaption of technology among the oldest-old cohort. Different patterns of use emerged for the different devices and depending on the living situation.

Current models of technology acceptance still focus on individual characteristics and often do not consider gerontological expertise. However, technology is considered as an important context characteristic in current models of ecological gerontology (e.g., Chaudhury & Oswald, 2019; Wahl & Gerstorf, 2018). Our results stress the relevance of the ecological perspective in research on technology adoption among the oldest-old. To ensure that technology acceptance research can make reliable statements about the technology acceptance of older adults, gerontological expertise should be given more intensive consideration in this research field.

On a methodological level, such considerations may include surveys on everyday life, for example, by using ambulatory assessments or digital diary studies (Brose & Ebner-Priemer, 2015). With this approach, the daily use of technology can be evaluated. This approach also allows for a more nuanced assessment of daily use of (and different uses of) technology. The advantages of such modern methods are that their findings will be ecologically valid because they are collected in the course of people's day-to-day lives and thus capture behaviors and experiences in real-life environments outside of research laboratories (Wrzus & Mehl, 2015).

From a social–political viewpoint, the low usage rates of ICT, especially among certain subgroups such as people in long-term care, can lead to new types of inequality in society. People without access to ICT are systematically excluded, and not using ICT devices means not being able to access certain types of information or use certain services, which in turn may affect people's daily lives and thus evoke a feeling of exclusion (Seifert et al., 2018). The effects of using and not using technology, as well as technology's relationships with well-being, require examination (Sims et al., 2017); the duration of use and past experiences with ICT devices should also be considered. Understanding the successful use of ICT over time is important because only the sustained use of such technology will provide the opportunity to profit from the "benefits of technology in our digitally based society" (Cotten, 2017, p. 825). These relationships have not been studied among the oldest-old cohort and thus form an important future research field.

Practical Implications

Our results have practical implications on different levels, among the most important of which is the topic of available infrastructure for ICT usage. Unintentional terminations of ICT use are more likely to occur when an older adult moves from a private home to long-term care facilities (Seifert et al., 2017). Nevertheless, the use of ICT may potentially influence the experience of living in long-term care institutions and could reduce the negative opinions of self-contained "closed" systems such as nursing homes (Goffman, 1961). For example, using a smartphone or tablet with internet access could better connect the residents of these institutions with the community and reduce the tendency toward segregation. The use of technologies may also help vulnerable older adults maintain feelings of subjective autonomy and mastery (Schulz et al., 2015).

Closely related is the question of whether learning opportunities that include ICT use by trained staff are available for people in private homes and in long-term care (Ragneskog & Gerdner, 2006). Older adults who wish to use ICT might be helped by offers of support and training to increase their self-efficacy and digital literacy skills (Cotten et al., 2016). Similar concepts as in the case of nursing care consultants for AT would be conceivable here. Older adults' special learning needs also need to be considered in the design of technologies (Czaja et al., 2019), and designers should pay attention to older people's technological skills.

Limitations

Our findings need to be interpreted by considering limitations caused by the study design and the analytical approach. The study was a cross-sectional survey, and we could only identify correlations; we were unable to identify causal relationships. For example, the use of ICT may positively affect functional health and not vice versa.

Our study was also limited to the items measured within the NRW80+ study we used. For example, we do not have any information on the available infrastructures (e.g., whether internet access is available in the long-term care facilities). Furthermore, information on ICT use within the last year does not allow a statement as to whether the devices were used online or offline. We also could not analyze the intensity of ICT use, and we only considered specific assistive and ICT devices, whereas Sum and colleagues (2008) have

recommended that differentiated evaluations are necessary. Our study also did not measure people's prior experiences with technology use and digital skills in general, so we could not analyze their levels of digital expertise and literacy.

Further studies should consider attitudes toward technology usage in more nuanced ways than was possible in the present research. For example, Lee et al. (2019) analyzed individual differences in technology attitudes (including interest, efficacy, and comfort) within a sample of 3,917 adults aged 18–98 years over a time period of 20 years. They showed that male gender, higher education, and more experience with technology had a positive effect on each of the attitudes that were analyzed in the study.

Conclusion

This study has reported findings on the use of AT and ICT based on the first representative statewide survey study among the oldest-old cohort in the German state of NRW. Our findings show differences regarding the use of AT and ICT between private homes and institutional settings, which emphasizes the importance of ecological perspectives in the research on technology adoption among the oldest-olds. The use of ICT was limited in long-term care institutions and influenced by both individual characteristics and environmental characteristics. Chronological age, functional health, education, and interest in technology were also found to be important predictors of ICT use. The use of AT was predicted by chronological age and functional health. The results will help to better understand the role of technologies and the digital divide among the very old cohort.

Authors' Note

The NRW80+ project is a key research area of "Aging and Demographic Change" (spokeswoman: Susanne Zank) of the Cologne Center for Ethics, Rights, Economics, and Social Sciences of health (ceres), which is directed by Christiane Woopen at the University of Cologne. Christian Rietz, Michael Wagner, Christiane Woopen, and Susanne Zank are members of the project board. All processes of the study were in accordance with the ethical standards of the ethics committee of the Medical Faculty of the University of Cologne (No. 17–169) and with the Helsinki Declaration of 1975 (in its most recently amended version). Informed consent was obtained from all of the participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research is part of the NRW80+ project, which is supported by the Ministry of Innovation, Science, and Research, North Rhine-Westphalia.

ORCID iD

Anna Schlomann https://orcid.org/0000-0003-0174-3490

References

Berkowsky, R. W., Sharit, J., & Czaja, S. J. (2018). Factors predicting decisions about technology adoption among older adults. *Innovation in Aging*, *1*(3), igy002. https://doi.org/10.1093/geroni/igy002

Bobillier Chaumon, M.-E., Michel, C., Tarpin Bernard, F., & Croisile, B. (2014). Can ICT improve the quality of life of elderly adults living in residential home care units? From actual impacts to hidden artefacts. *Behaviour & Information Technology*, *33*(6), 574–590. https://doi.org/10.1080/0144929X.2013.832382

Brose, A., & Ebner-Priemer, U. W. (2015). Ambulatory assessment in the research on aging: Contemporary and future applications. *The Gerontology*, *61*(4), 372–380. https://doi.org/10.1159/000371707

Chaudhury, H., & Oswald, F. (2019). Advancing understanding of person-environment interaction in later life: One step further. *Journal of Aging Studies*, *51*, 100821. https://doi.org/10.1016/j.jaging.2019.100821

Chen, K., & Chan, A. H. S. (2011). A review of technology acceptance by older adults. *Gerontechnology*, *10*(1), 1–12. https://doi.org/10.4017/gt.2011.10.01.006.00

Chen, K., & Chan, A. H. S. (2014). Gerontechnology acceptance by elderly Hong Kong Chinese: A senior technology acceptance model (STAM). *Ergonomics*, *57*(5), 635–652. https://doi.org/10.1080/00140139.2014.895855

Cotten, S. R. (2017). Examining the roles of technology in aging and quality of life. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *72*(5), 823–826. https://doi.org/10.1093/geronb/gbx109

Cotten, S. R., Yost, E. A., Berkowsky, R. W., Winstead, V., & Anderson, W. A. (2016). *Designing technology training for older adults in continuing care retirement communities*. https://doi.org/10.1201/9781315382463

Czaja, S. J., Boot, W. R., Charness, N., & Rogers, W. A. (2019). *Designing for older adults: Principles and creative human factors approaches*. CRC Press.

Czaja, S. J., Boot, W. R., Charness, N., Rogers, W. A., & Sharit, J. (2018). Improving social support for older adults through technology: Findings from the PRISM randomized controlled trial. *The Gerontologist*, *58*(3), 467–477. https://doi.org/10.1093/geront/gnw249

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: Findings from the center for research and education on aging and technology enhancement (CREATE). *Psychology and Aging*, *21*, 333–352. http://dx.doi.org/10.1037/0882-7974.21.2.333

Davies, K., Collerton, J. C., Jagger, C., Bond, J., Barker, S. A. H., Edwards, J., Hughes, J., Hunt, J. M, & Robinson, L. (2010). Engaging the oldest old in research: Lessons from the Newcastle 85+ study. *BMC Geriatrics*, *10*, 64. https://doi.org/10.1186/1471-2318-10-64

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

Forsman, A. K., & Nordmyr, J. (2017). Psychosocial links between internet use and mental health in later life: A systematic review of quantitative and qualitative evidence. *Journal of Applied Gerontology*, *36*(12), 1471–1518. https://doi.org/10.1177/0733464815595509

Francis, J., Ball, C., Kadylak, T., & Cotten, S. R. (2019). Aging in the digital age: Conceptualizing technology adoption and digital inequalities. In B. B. Neves & F. Vetere (Eds.), *Ageing and digital technology* (pp. 35–49). https://doi.org/10.1007/978-981-13-3693-5_3

Garçon, L., Khasnabis, C., Walker, L., Nakatani, Y., Lapitan, J., Borg, J., Ross, A., & Velazquez Berumen, A. (2016). Medical and assistive health technology: Meeting the needs of aging populations. *The Gerontologist*, *56*(Suppl. 2), S293–S302. https://doi.org/10.1093/geront/gnw005

German Federal Ministry of Health. (2019). Beratung im pflegefall [Consultation in case of care needs]. https://www.bundesgesundheitsministerium.de/themen/pflege/online-ratgeber-pflege/beratung-im-pflegefall.html

Goffman, E. (1961). *Asylums: Essays on the social situation of mental patients and other inmates*. Anchor Books.

Harrington, C. N., Mitzner, T. L., & Rogers, W. A. (2015). Understanding the role of technology for meeting the support needs of older adults in the USA with functional limitations. *Gerontechnology*, *14*(1), 21–31.

Hunsaker, A., & Hargittai, E. (2018). A review of internet use among older adults. *New Media & Society*, 1–18. https://doi.org/10.1177/1461444818787348

Initiative D21. (2019). *D21 Digital Index 2018/2019: Jährliches Lagebild zur digitalen Gesellschaft* [D21 Digital Index 2018/2019: Annual overview of the digital society]. https://initiative d21.de/app/uploads/2019/01/d21_index2018_2019.pdf

International Organization for Standardization. (2016). *Assistive products for persons with disability: Classification and terminology (ISO 9999:2016)*. https://www.iso.org/standard/60547.html

Kalbe, E., Kessler, J., Calabrese, P., Smith, R., Passmore, A. P., Brand, M. A., & Bullock, R. (2004). DemTect: A new, sensitive cognitive screening test to support the diagnosis of mild cognitive impairment and early dementia. *International Journal of Geriatric Psychiatry*, *19*(2), 136–143.

Kamin, S. T., & Lang, F. R. (2018). Internet use and cognitive functioning in late adulthood: Longitudinal findings from the Survey of Health, Ageing and Retirement in Europe (SHARE). *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, gby123. https://doi.org/10.1093/geronb/gby123

Kelfve, S., Thorslund, M., & Lennartsson, C. (2013). Sampling and non-response bias on health-outcomes in surveys of the oldest old. *European Journal of Ageing*, *10*(3), 237–245. https://doi.org/10.1007/s10433-013-0275-7

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management*, *43*(6), 740–755. https://doi.org/10.1016/j.im.2006.05.003

König, R., Seifert, A., & Doh, M. (2018). Internet use among older Europeans: An analysis based on SHARE data. *Universal Access in the Information Society*, *17*, 621–633. https://doi.org/10.1007/s10209-018-0609-5

Lawton, M. P. (1982). Competence, environmental press, and the adaptation of older people. In M. P. Lawton, P. G. Windley, & T. O. Byerts (Eds.), *Aging and the environment* (pp. 33–59). Springer.

Lee, C. C., Czaja, S. J., Moxley, J. H., Sharit, J., Boot, W. R., Charness, N., & Rogers, W. A. (2019). Attitudes toward computers across adulthood from 1994 to 2013. *The Gerontologist*, *59*(1), 22–33. https://doi.org/10.1093/geront/gny081

Marangunić, N., & Granić, A. (2015). Technology acceptance model: A literature review from 1986 to 2013. *Universal Access in the Information Society*, *14*(1), 81–95. https://doi.org/10.1007/s10209-014-0348-1

Mitzner, T. L., Savla, J., Boot, W. R., Sharit, J., Charness, N., Czaja, S. J., & Rogers, W. A. (2018). Technology adoption by older adults: Findings from the PRISM trial. *The Gerontologist*, *59*(1), 34–44. https://doi.org/10.1093/geront/gny113

Moyle, W., Jones, C., Murfield, J., Dwan, T., & Ownsworth, T. (2018). "We don't even have Wi-Fi": A descriptive study exploring current use and availability of communication technologies in residential aged care. *Contemporary Nurse*, *54*(1), 35–43. https://doi.org/10.1080/10376178.2017.1411203

Peek, S. T. M., Wouters, E. J. M., Van Hoof, J., Luijkx, K. G., Boeije, H. R., & Vrijhoef, H. J. M. (2014). Factors influencing acceptance of technology for aging in place: A systematic review. *International Journal of Medical Informatics*, *83*(4), 235–248. https://doi.org/10.1016/j.ijmedinf.2014.01.004

Peine, A., & Neven, L. (2019). From intervention to co-constitution: New directions in theorizing about aging and technology. *The Gerontologist*, *59*(1), 15–21. https://doi.org/10.1093/geront/gny050

Pew Research Center. (2018). Social media use continues to rise in developing countries but plateaus across developed ones. http://www.pewglobal.org/2018/06/19/2-smartphone-ownership-on-the-rise-in-emerging-economies/

Ragneskog, H., & Gerdner, L. (2006). Competence in nursing informatics among nursing students and staff at a nursing institute in Sweden. *Health Information and Libraries Journal*, *23*(2), 126–132. https://doi.org/10.1111/j.1471-1842.2006.00643.x

Reisberg, B., Ferris, S. H., de Leon, M. J., & Crook, T. (1982). The Global Deterioration Scale for assessment of primary degenerative dementia. *The American journal of psychiatry*, *139*(9), 1136–1139. https://doi.org/10.1176/ajp.139.9.1136

Rikard, R. V., Berkowsky, R. W., & Cotten, S. R. (2018). Discontinued information and communication technology usage among older adults in continuing care retirement communities in the United States. *Gerontology*, *64*(2), 188–200. https://doi.org/10.1159/000482017

Sackmann, R., & Winkler, O. (2013). Technology generations revisited: The internet generation. *Gerontechnology*, *11*(4), 493–503. https://doi.org/10.4017/gt.2013.11.4.002.00

Schulz, R., Wahl, H. W., Matthews, J. T., De Vito Dabbs, A., Beach, S. R., & Czaja, S. J. (2015). Advancing the aging and technology agenda in gerontology. *The Gerontologist*, *55*, 724–734. https://doi.org/10.1093/geront/gnu071

Seifert, A., Doh, M., & Wahl, H. W. (2017). They also do it: Internet use by older adults living in residential care facilities. *Educational*

Gerontology, *43*(9), 451–461. https://doi.org/10.1080/03601277.2017.1326224

Seifert, A., Hofer, M., & Rössel, J. (2018). Older adults' perceived sense of social exclusion from the digital world. *Educational Gerontology*, *44*(12), 775–785. https://doi.org/10.1080/03601277.2019.1574415

Seifert, A., & Schelling, H. R. (2018). Seniors online: Attitudes toward the internet and coping with everyday life. *Journal of Applied Gerontology*, *37*(1), 99–109. https://doi.org/10.1177/0733464816669805

Sims, T., Reed, A. E., & Carr, D. C. (2017). Information and communication technology use is related to higher well-being among the oldest-old. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *72*(5), 761–770. https://doi.org/10.1093/geronb/gbw130

Sum, S., Mathews, R. M., Hughes, I., & Campbell, A. (2008). Internet use and loneliness in older adults. *CyberPsychology & Behavior*, *11*(2), 208–211. https://doi.org/10.1089/cpb.2007.0010

Wagner, M., Rietz, C., Kaspar, R., Janhsen, A., Geithner, L., Neise, M., Kinne-Wall, C., Woopen, C., & Zank, S. (2018). Quality of life of the very old: Survey on quality of life and subjective well-being of the very old in North Rhine-Westphalia (NRW80+). *Zeitschrift für Gerontologie und Geriatrie*, *51*(2), 193–199. https://doi.org/10.1007/s00391-017-1217-3

Wahl, H.-W., & Gerstorf, D. (2018). A conceptual framework for studying Context Dynamics in Aging (CODA). *Developmental Review*, *50*, 155–176. https://doi.org/10.1016/j.dr.2018.09.003

Wahl, H.-W., Iwarsson, S., & Oswald, F. (2012). Aging well and the environment: Toward an integrative model and research agenda for the future. *The Gerontologist*, *52*(3), 306–316. https://doi.org/10.1093/geront/gnr154

Wrzus, C., & Mehl, M. R. (2015). Lab and/or field? Measuring personality processes and their social consequences. *European Journal of Personality*, *29*(*2*), 250–271. https://doi.org/10.1002/per.1986

Yusif, S., Soar, J., & Hafeez-Baig, A. (2016). Older people, assistive technologies, and the barriers to adoption: A systematic review. *International Journal of Medical Informatics*, *94*, 112–116. https://doi.org/10.1016/j.ijmedinf.2016.07.004

Author Biographies

Anna Schlomann is a postdoctoral researcher at the Network Aging Research at Heidelberg University. She studied sociology and empirical social research. Her research focuses on technology acceptance among older adults and the social impact of digitization in the context of aging populations.

Alexander Seifert is a senior research fellow at the University of Fribourg and University of Zurich. His research interests include the well-being outcomes associated with technology use among older adults and the social participation of older people in society.

Susanne Zank is a full professor at the University of Cologne and head of the Chair of Rehabilitative Gerontology. Her research focuses on the living conditions of very old people, burden and intervention research with caring relatives of persons with dementia, and intervention and rehabilitation research with older adults.

Christian Rietz is a full professor at Heidelberg University of Education and head of the Service Center Research Methods. He is an expert for methods and methodologies of quantitative research, especially with mixed method approaches. His research interest is on digital transformation processes and its effects.