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ICT use and well-being in the oldest-old: Evidence from the representative German D80+ study

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ABSTRACT

While prior research has suggested that Information and communication technologies (ICT) use may be associated with enhanced well-being in older adults, evidence for the oldest-old population (aged 80+) remains limited. This study investigates the relationship between ICT use and subjective well-being in adults aged 80 and older using data from the representative German D80+ survey ($n = 2,174$). Building on earlier findings from a regional survey, we aim to replicate previous results and extend them by including an additional indicator of subjective well-being (i.e., positive affect). ICT use was categorized into internet-based use, non-internet-based use, and no ICT use. Moreover, descriptive analyses were used to explore different purposes of internet use (social vs. instrumental) to generate hypotheses for future research. Multiple linear regressions, including relative weights analyses, were conducted, controlling for sociodemographic variables, subjective health, and indicators of social inclusion. The study's results indicate that internet-based ICT use is significantly associated with higher positive affect and lower anomie even after accounting for covariates. No significant association was found between ICT use by the oldest-old population and loneliness. These findings suggest that internet-based ICT may serve as a meaningful tool to support the oldest-old's well-being.

With populations aging worldwide, promoting older adults' well-being is now a major social priority. As life expectancies increase and birth rates decline, the proportion of individuals aged 80 years and older, the 'oldest-old,' is expanding more rapidly than any other age group in many industrialized nations (European Commission, 2020; World Health Organization, 2024). This shift in demographics underscores the importance of understanding how well-being can be maintained or enhanced in very late life, particularly in light of the heightened vulnerability to the physical, cognitive, and social challenges associated with very old age (Baltes & Smith, 2003; Gerstorf et al., 2008; Marengoni et al., 2011; Salthouse, 2013).

One area of growing interest in this context is the role of digital technologies in fostering and maintaining well-being. Aggarwal et al.'s (2020) literature review found that internet use was significantly linked to higher life satisfaction and lower levels of poor health in older adults in the majority of studies. Information and communication technologies (ICT), particularly internet-based ICT, have increasingly been recognized as tools that may help older adults preserve autonomy, maintain social connections, and access important resources (Damant et al., 2017; Forsman et al., 2018; Hülür & Macdonald, 2020).

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ICT encompass devices such as mobile phones, computers, and smart devices that support access to information and communication services. Internet-based ICT refers to technologies that enable online access and interaction, such as smartphones, tablets, or wearable devices like smart watches and fitness trackers. These technologies may offer diverse forms of instrumental and emotional support in advanced age (Antonucci et al., 2017; Schlomann, Seifert, Zank, Woopen, et al., 2020).

Theoretical framework

Theoretical frameworks from the fields of gerontology, gerontechnology and lifespan psychology offer helpful perspectives for better understanding the potential links between ICT use and well-being in very late life.

The conceptual model of environmental gerontology (Wahl et al., 2012) is a prominent framework that emphasizes the dynamic interplay between individuals and their surrounding environments. According to this model, a good fit between person and environment contributes positively to well-being. The environment in this sense is not limited to physical contexts but also includes social, cultural, and increasingly digital aspects (Wahl & Gerstorf, 2018). As technological environments have rapidly evolved, the oldest-old, who grew up before the digital era, face greater challenges with adapting to these new digital contexts than younger cohorts. However, the successful use of modern technologies may represent an adaptive strategy that fosters a more favorable person – environment fit in very old age. Specifically, the use of internet-based ICT may promote such a fit by helping individuals stay connected, informed, and engaged in a world that is increasingly shaped by digital infrastructures (Hülür & Macdonald, 2020; Kobayashi et al., 2015). In this context, the present study also relates to the field of gerontechnology, which focuses on the design and adaptation of technologies to support independent living, safety, health, and social participation in later life (International Society for Gerontechnology, 2026). From a gerontechnological perspective, ICT may serve as an important resource for maintaining autonomy, participation, and social connectedness in advanced old age.

In addition, two lifespan theories in gerontology, the socioemotional selectivity theory (SST; Carstensen et al., 1999) and the life-span theory of control (Heckhausen et al., 2010), offer complementary explanations for the potential benefits of ICT use in very old age. SST posits that individuals' goals and motivations shift as a function of their perceived future time. When individuals see time as limited, they increasingly prioritize emotionally meaningful goals and experiences, such as maintaining close social relationships and enhancing emotional well-being (Carstensen, 2006). Given that very old adults are likelier to perceive time as constrained compared to younger persons, they may value experiences that support social connectedness and positive affect. Internet-based ICT can facilitate the achievement of these goals by providing access to entertainment and by enabling communication through tools such as instant messaging and video calls. This may be particularly important for the oldest-old, who often face mobility limitations that make in-person interactions more difficult (Baltes & Smith, 2003; Marengoni et al., 2011; Salthouse, 2013). By helping the oldest-old maintain social ties despite these limitations, ICT use may support such goal fulfillment and, in turn, contribute to enhanced well-being, as predicted by SST.

The life-span theory of control (Heckhausen et al., 2010) also provides a compelling lens through which the potential benefits of ICT use can be interpreted. According to this theory, the pursuit and maintenance of control is a fundamental human motivation across the lifespan and is closely linked to subjective well-being. However, as people age, physical and cognitive decline may restrict their ability to exert control over their environments. Older adults seeking to preserve their well-being are thought to shift their focus from unattainable to attainable goals and to adopt compensatory strategies (Heckhausen et al., 2010). ICT use may serve as one such strategy by enabling individuals to perform tasks that would otherwise be difficult or impossible (e.g., online shopping, online banking, or digital communication). These technologies may help individuals maintain a sense of autonomy and efficacy despite their functional limitations. Moreover, ICT use may facilitate adaptive goal disengagement by helping users identify achievable

alternatives and avoid pursuing goals that no longer match their current capabilities; thus, the life-span theory of control also supports the hypothesis that internet-based ICT use is positively associated with well-being in very old age.

In summary, all three frameworks converge on the idea that internet-based ICT use may promote well-being in very late life by supporting person – environment fit, enabling emotionally meaningful experiences, and preserving the oldest old's sense of control.

Digital inclusion and exclusion in very old age

As physical mobility and in-person social contact are likely to decrease in very old age, digital technologies may help bridge these gaps and support such individuals' participation in everyday life. For example, internet-based ICT use may enable online shopping and banking, facilitate access to digital healthcare services, or help maintain social contacts with family and friends through video calls and messaging platforms (Kobayashi et al., 2015; Soundararajan et al., 2023); therefore, prior studies have proposed ICT use as a factor contributing to higher levels of well-being in later life.

Despite these potential benefits, the oldest-old remain significantly underrepresented among ICT users. In Germany, only around a third of individuals aged 80 and older report using the internet, compared to nearly 90% of the general population (Reissmann et al., 2023). This 'grey digital divide' (Mubarak & Suomi, 2022) reflects the age-related inequalities in access to digital resources, digital skills, and usage confidence (Charness & Boot, 2022; Hauk et al., 2018; Mitzner et al., 2019). Factors such as health problems, sensory limitations, cognitive decline, and low technology self-efficacy may further hinder the uptake of new technologies in very old age (Anderson & Perrin, 2017; Charness & Boot, 2022). At the same time, individuals who engage with digital tools may experience benefits not only in terms of practical functioning but also in the social domain (Seifert & Cotten, 2022).

Previous research has largely focused on older adults as a single group, often combining individuals aged 65 and above without accounting for meaningful heterogeneity across this age range (Key & Culliney, 2018; Sims et al., 2017) and potentially underrepresenting individuals in very old age. However, substantial differences in life circumstances, health status, and social resources exist between the young-old (i.e., 65–79 years) and the oldest-old (i.e., 80+ years) (Cohen-Mansfield et al., 2013; Kaspar et al., 2023). Disentangling these differences is essential to identifying age-specific needs and potential for digital inclusion.

Existing research on ICT use and well-being

Empirical findings on the relationship between ICT use and well-being in older adults are mixed. Some studies have found no significant associations (e.g., Aggarwal et al., 2020; Berner et al., 2012) between the two, while others have observed that ICT use, particularly internet-based ICT use, positively affects well-being in older adults (e.g., Damant et al., 2017; Fang et al., 2018; Lee, 2024). For instance, Lee (2024) reported that internet use is associated with greater life satisfaction and fewer health complaints. Some studies have produced mixed findings depending on the outcome considered (e.g., Elliot et al., 2014), suggesting the importance of differentiating between specific dimensions of well-being.

Furthermore, few studies have distinguished between internet-based ICT use and offline ICT use (e.g., using non-connected devices), which may contribute to inconsistent results (Schlomann, Seifert, Zank, Woopen, et al., 2020). The present study addresses these issues by considering multiple well-being indicators and explicitly differentiating between types of ICT use. Both theoretical arguments and existing evidence indicate that oldest-old individuals who use internet-based ICT report higher well-being than non-users of internet-based ICT or persons without internet access.

ICT use and positive affect

Positive affect reflects experiences of joy, interest, or contentment and is a key component of subjective well-being. SST (Carstensen et al., 1999) posits that older adults increasingly prioritize emotionally meaningful goals, such as maintaining positive emotional states. ICT, especially when used to form social connections or engage in stimulating activities, can support these goals. Internet-based ICT use offers users access to stimulating content, social engagement, and opportunities for learning or entertainment, all of which can foster positive emotions (Fang et al., 2018). Empirical studies have found that older adults who use ICT report higher levels of positive affect and life satisfaction than older adults who do not use ICT (Chopik, 2016; Lee, 2024). These findings support the assumption that ICT can contribute to emotional well-being in very old age. Accordingly, the oldest-old internet users are expected to report higher levels of positive affect than those who do not use ICT or only use offline ICT.

ICT use and loneliness

Loneliness is highly prevalent among the oldest-old (Hawkley et al., 2022) and is linked to negative health outcomes. While some studies have shown that internet use is related to lower levels of loneliness (e.g., Cotten et al., 2013; Schlomann, Seifert, Zank, Woopen, et al., 2020; Yu et al., 2021), others have reported null or even negative effects (Atzendorf & Gruber, 2022). One possible explanation for this is that the purpose of ICT use matters and only social uses of the internet appear to reduce loneliness (Rennoch et al., 2023; Seifert, 2025). However, due to several theoretical assumptions and empirical findings, we expect internet-based ICT use to be associated with lower levels of loneliness.

ICT use and anomie

Anomie refers to feelings of disconnection or exclusion from society and is rather prevalent among the oldest-old (Key & Culliney, 2018). ICT use may buffer against anomie by enabling participation in digital society and improving access to information and services (Schlomann, Seifert, Zank, Woopen, et al., 2020). Prior research has found that internet users feel more socially included and less disoriented in the modern digital world (Castellacci & Tveito, 2018); thus, we expect internet-based ICT use to be linked to lower levels of anomie.

Research gaps and current study

While several studies have examined ICT use and well-being among older adults, there remains a lack of evidence specifically focused on the oldest-old. Considering both the unique life circumstances of this population and the potential of ICT to support well-being and active aging (Seifert & Cotten, 2022), research addressing this gap is crucial. Building on earlier regional work in North-Rhine Westphalia (NRW80+ survey; e.g., Rennoch et al., 2023; Schlomann, Seifert, Zank, & Rietz, 2020; Schlomann, Seifert, Zank, Woopen, et al., 2020), the current study investigates the association between internet-based ICT use and specific dimensions of subjective well-being (i.e., positive affect, loneliness, and anomie) using data from the representative German D80+ study. In addition to studying these associations, this study also explores the effect of further control variables, such as indicators of social inclusion and individual characteristics, to develop a differentiated understanding of digital engagement in very late life.

Materials and methods

Study design and sample

This study is a secondary data analysis based on the first nationwide representative survey of individuals aged 80 and older living in Germany, the D80+ study (Albrecht et al., 2023). The D80+

study received approval from the Ethics Committee of the Medical Faculty of the University of Cologne (protocol number: 19-1387_1), and all participants gave their informed consent. Due to the COVID-19 pandemic, modifications were necessary in the study design; in-person interviews were replaced by a two-phase survey design (see below). Data collection took place between November 2020 and April 2021. Further details on the study and its methods are provided in the work of Prussog-Wagner et al. (2022).

The first phase of data collection consisted of a written postal questionnaire (Module 1: high-priority, self-administered items), while the second phase involved a telephone survey (Module 2: remaining high-priority items and additional content not suitable for completion via post). The study's participants were recruited from community-dwelling individuals and residents of institutional long-term care aged 80 years and older.

The gross sample was drawn using a multistage, disproportional stratified sampling strategy by sex and age. A total of 60% of Module 1 respondents were successfully contacted for Module 2, resulting in 3,271 fully completed interviews across both modules. The interviews were conducted by trained interviewers with prior experience working with very old or disabled populations and were supported by extensive training and quality supervision. As the key variable of ICT use was only included in Module 2, only those respondents who completed the full questionnaire themselves (i.e., not via proxy interviews) were included in this paper's analyses. After applying inclusion criteria, performing listwise deletion for missing data, and excluding multivariate outliers ($p < .001$, Mahalanobis distance; see approach in Hair et al., 2010), the final analytic sample for this paper consisted of $N = 2,174$ respondents (mean age = 85.28, $SD = 3.56$; 57.9% female; 3.6% institutional long-term care).

Measures

ICT use

The participants were asked about whether they had used any of the following technologies in the past 12 months (0 = no, 1 = yes): computers/laptops, smartphones, mobile phones, tablets, or fitness trackers. Building on the work of Schlomann, Seifert, Zank, Woopen, et al. (2020), we categorized ICT use into three groups:

- (1) **No ICT use:** used none of the aforementioned devices in the past 12 months;
- (2) **Offline ICT use:** used mobile phones or computers/laptops, but not internet-enabled devices;
- (3) **Online ICT use:** accessed the internet or used at least one of the following: smartphones, tablets, fitness trackers.

Participants who used online ICT were further asked whether they had used the internet in the past 3 months for: (a) sending/receiving emails, (b) searching for health information, (c) using social networks, and (d) buying/selling products or services. Online ICT use was categorized into social (email, social networks) and instrumental (health information, e-commerce) purposes based on the answers. Mutually exclusive groups (i.e., internet use exclusively for instrumental purposes or exclusively for social purposes) were created for frequency analyses.

Well-being indicators

Positive affect was measured using the five-item positive affect subscale from the short version of the Positive and Negative Affect Schedule (PANAS; Mackinnon et al., 1999). Participants were asked about how often they experienced the following feelings in the last 12 months: 'enthusiastic,' 'attentive,' 'joyfully excited, expectant,' 'stimulated,' and 'determined.' Answers were provided on a five-point Likert scale ranging from 1 (*never*) to 5 (*very often*). Internal consistency was acceptable ($\alpha = .79$).

Loneliness was assessed with a single item ('How often did you feel lonely during the past week?') on a four-point scale (1 = *never/almost never* to 4 = *always/almost always*). The reliability and validity of such single-item measures and their high correlation with scores of multi-item scales have been demonstrated in a recent study (Mund et al., 2023), suggesting that single-item measures are robust and trustworthy measures of loneliness.

Anomie was assessed using a three-item scale adapted from Gümüs et al. (2004) that asked the following questions: 'Do you have the feeling that you are coping less and less with today's social way of life?', 'Do you feel that your own values are becoming less and less compatible with the values of today's society?', and 'Do you have the feeling that today's society is changing so quickly that you no longer know how to orient yourself in society?' Each item was rated on a four-point scale from 1 (*does not apply*) to 4 (*fully applies*), with higher scores reflecting greater perceived anomie. A mean score was used in the analyses. The scale showed acceptable internal consistency ($\alpha = .79$).

Covariates

Indicators of social inclusion and individual characteristics were included as control variables. Social inclusion is known to be closely related to various aspects of well-being, including loneliness, anomie, and autonomy. For example, global survey data show that positive emotions are closely linked to the fulfillment of social needs, including social contact and respect (Tay & Diener, 2011). Building on the work of Schlomann, Seifert, Zank, Woopen, et al. (2020), we included multiple indicators of social inclusion: frequency of social contact (a five-point scale from *never* to *very often*), participation in group activities outside the family (a six-point scale from ranging from 0 = *never* and 5 = *daily*) and the size of one's social network (number of persons in a personal network in absolute numbers). Additionally, social support received was measured using a three-item subscale from the German Ageing Survey (DEAS; Engstler et al., 2015). The DEAS's items assessed support over the past 12 months, including financial or material gifts, help with tasks (excluding paid services), and emotional support (e.g., being comforted or encouraged). Responses were coded dichotomously (0 = *no*, 1 = *yes*), and a mean score across the items was used as an indicator of received support, with higher scores reflecting greater support.

Prior research has identified associations between individual characteristics and the use of new technologies in old age (e.g., König et al., 2018). Several studies have also linked better self-rated health, participation in the labor force, and non-institutional living arrangements to higher well-being (Drageset et al., 2011; McKee-Ryan et al., 2005; Ngamaba et al., 2017). Furthermore, very old women are likelier than very old men to be widows and to report higher levels of loneliness (Dahlberg et al., 2022; Yang & Gu, 2021). We therefore controlled for individual characteristics that may influence well-being, such as age (continuous in years, mean-centered), gender (ref. female), education measured based on the International Standard Classification of Education (ISCED; low [ref.], middle, and high), living arrangements (long-term care [ref.] or no long-term care), subjective health status (single item: 'How would you describe your general health over the past four weeks?' answered on a four-point scale: 1 = *very poor* to 4 = *very good*), and a variable that captures participation in the labor force (never employed [ref.] or employed at any point in time).

Statistical analysis

All main analyses were conducted using SPSS 28. The weighting procedures included design weights (sampling probabilities) and calibration (non-response adjustment and marginal adjustments for representativeness based on official population statistics and regional classifications extracted from the Regionale Standards of the German Federal Statistical Office (Destatis) and associated research organizations; Behrens et al. (2019).

Descriptive statistics – individual characteristics and indicators of social inclusion – were computed for both ICT user groups and non-ICT users. Group differences in continuous variables were

examined using one-way analyses of variance (ANOVAs), with ICT use serving as the between-subjects factor. Where the overall test scores were significant, Bonferroni-adjusted post hoc comparisons were conducted to identify pairwise group differences. The associations between ICT use and categorical individual characteristics were analyzed using chi-square tests of independence. Bonferroni-adjusted post hoc comparisons were performed for significant chi-square results, and Cramer's V was reported as a measure of effect size.

To compare different purposes of internet use (i.e., social and instrumental purposes) within the same respondents, a McNemar test was conducted for paired dichotomous variables. This procedure was chosen because the indicators of internet use purposes were coded as binary responses (yes/no) and represented related within-subject measures.

Multiple linear regressions were conducted to examine associations between ICT use and each dependent variable (i.e., positive affect, loneliness, and anomie). Stepwise models included ICT use in the first step, followed by social inclusion variables and, finally, individual characteristics. ICT use was considered in three groups (i.e., no ICT use, offline ICT use, and internet-based ICT use; see above).

Relative weights analyses (RWAs; Tonidandel & LeBreton, 2011) were conducted to assess the proportional contribution of each predictor to the explained variance. The RWAs were performed using a free web-based application 'RWA-Web' provided by Tonidandel and LeBreton (2015). Due to computational constraints, the RWAs were bootstrapped with 2,500 iterations.

Results

Descriptive statistics and bivariate associations

Descriptive statistics of ICT user groups as well as non-ICT users in terms of individual characteristics and social indicators are presented in Table 1. Of the total sample ($N = 2,174$), 58.6% of participants reported using internet-based ICT (online ICT), 32.3% used ICT without internet access (offline ICT), and 9.1% reported not using ICT at all. Participants who used online ICT were, on average, younger ($M = 84.68$, $SD = 3.27$) than those in the offline ICT group ($M = 86.01$, $SD = 3.76$) or those who did not use ICT ($M = 86.46$, $SD = 3.87$).

A one-way ANOVA revealed significant age differences between the three ICT usage groups, $F(2, 2170) = 45.20$, $p < .001$, $\eta^2 = .04$. Post hoc comparisons with Bonferroni correction indicated

Table 1. Sample description and ICT use.

		No ICT	Offline ICT	Online ICT
		9.1	32.3	58.6
Total ($n = 2174$)	M (SD) / %			
Age	<i>M (SD)</i>	86.46 (3.87)	86.01 (3.76)	84.68 (3.27)
Gender	% female	11.4	36.7	51.9
	% male	6.0	26.2	67.8
Education	% low level	15.4	43.9	40.7
	% medium level	9.3	34.2	56.5
	% high level	5.2	22.9	72.0
Housing situation	% private home	9.4	31.6	59.0
	% long-term care	0.0	51.9	48.1
Care level	% no care level	8.3	28.6	63.1
	% any care level	12.0	39.6	48.4
Participation in the labor force	% employed at any point in time	9.0	31.8	59.2
	% never employed	10.6	57.4	31.9
Subjective health	% very bad	27.3	36.4	36.4
	% rather bad	10.5	37.4	52.1
	% rather good	8.2	31.1	60.8
	% very good	4.6	19.7	75.7
Frequency: participation in social activities	<i>M (SD)</i>	0.61 (1.21)	0.73 (1.33)	0.85 (1.41)
Frequency: time with other people	<i>M (SD)</i>	2.16 (0.97)	2.35 (0.89)	2.42 (0.87)
Received social support	<i>M (SD)</i>	0.55 (0.28)	0.60 (0.26)	0.60 (0.27)
Number of persons in personal network	<i>M (SD)</i>	7.51 (5.83)	7.70 (6.21)	9.61 (6.64)

Note: ICT = information and communication technologies; *M* = mean; *SD* = standard deviation, percentages in row.

that individuals using internet-based ICT were significantly younger than those who did not use ICT ($p < .001$) or used ICT without internet ($p < .001$).

Chi-square tests with Bonferroni-corrected post hoc comparisons were conducted, revealing significant associations between ICT use and various other individual characteristics. ICT use was associated with gender, $\chi^2(2) = 57.22$, $p < .001$, $V = .16$, with men being likelier than women to use internet-based ICT and less likely than women to report no ICT use or non-internet ICT use ($p < .001$). Similarly, higher educational achievement was linked to more frequent internet-based ICT use and less nonuse or offline ICT use, $\chi^2(4) = 105.88$, $p < .001$, $V = .16$.

ICT use also varied significantly by living arrangements, $\chi^2(2) = 18.34$, $p < .001$, $V = .09$, with individuals residing in private households more often reporting no ICT use ($p < .001$) and less use of ICT without the internet ($p < .001$) than those in institutional care. A similar pattern was observed for previous employment status, $\chi^2(2) = 15.34$, $p < .001$, $V = .08$. Individuals who were employed at any point in their life were likelier to use internet-based ICT ($p < .001$). Health status was also associated with ICT use, $\chi^2(6) = 57.49$, $p < .001$, $V = .12$. Those in poorer health were likelier to report no ICT use or ICT use without the internet, while better health was linked to more frequent use of internet-based ICT ($p < .001$).

One-way ANOVAs were used to test differences in indicators of social inclusion. Social activity frequency differed by ICT use, $F(2, 2170) = 3.75$, $p = .024$, $\eta^2 = .003$; however, Bonferroni-corrected post hoc tests showed no significant group differences ($p \geq .063$), which was consistent with the small effect size. The amount of time spent with others also varied significantly, $F(2, 2170) = 7.86$, $p < .001$, $\eta^2 = .007$. Post hoc tests indicated that non-users spent less time with others than both offline ($p = .024$) and online ICT users ($p < .001$).

Received social support differed significantly by ICT use, $F(2, 2170) = 3.40$, $p = .033$, $\eta^2 = .003$, with non-users reporting less support than both offline ($p = .047$) and online ICT users ($p = .033$). Lastly, network size showed significant differences across the groups, $F(2, 2170) = 24.41$, $p < .001$, $\eta^2 = .022$, with online ICT users reporting significantly larger networks than both non-users and offline users ($p < .001$).

Table 2 presents the mean scores for three domains of subjective well-being (i.e., positive affect, loneliness, and anomie across the ICT user groups). Participants who used online ICT reported the highest levels of positive affect ($M = 3.27$, $SD = 0.62$) and the lowest levels of loneliness ($M = 1.49$, $SD = 0.65$) and anomie ($M = 2.41$, $SD = 0.78$). In contrast, individuals who did not use any ICT scored lowest on positive affect ($M = 3.01$, $SD = 0.78$) and highest on anomie ($M = 2.78$, $SD = 0.83$), suggesting a less favorable well-being profile relative to other participants. Offline ICT users indicated intermediate values: positive affect ($M = 3.21$, $SD = 0.66$), loneliness ($M = 1.59$, $SD = 0.66$), and anomie ($M = 2.57$, $SD = 0.83$).

One-way ANOVAs revealed significant group differences between ICT user groups for all three well-being indicators (all $p < .001$). Bonferroni-adjusted post hoc comparisons indicated that both online ($p < .001$) and offline ($p < .001$) ICT users scored significantly higher on positive affect than non-users. Online ICT users reported significantly lower loneliness scores than both offline ($p = .015$) ICT users and non-users ($p = .002$), whereas the latter two did not differ significantly between themselves. All three groups differed significantly in terms of anomie ($.001 < p < .005$), with online ICT users reporting the lowest scores and non-users reporting the highest.

Table 2. Domains of subjective well-being within the ICT user groups.

	Positive Affect		Loneliness		Anomie	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total	3.23	0.66	1.54	0.67	2.49	0.81
No ICT	3.01	0.78	1.63	0.79	2.78	0.83
Offline ICT	3.21	0.66	1.59	0.66	2.57	0.83
Online ICT	3.27	0.62	1.49	0.65	2.41	0.78

Note: $N = 2,174$; ICT = information and communication technologies; M = mean; SD = standard deviation, percentages in row.

Hierarchical regression analyses predicting positive affect, loneliness, and anomie

Hierarchical linear regressions were conducted for each well-being outcome variable – positive affect, loneliness, and anomie – to further examine these associations and to consider the effects of control variables. Each model included three steps: Step 1 included ICT use categories (no ICT, offline ICT, and online ICT); step 2 added variables related to social inclusion (frequency of social contact, time with other people, received social support, and number of persons in personal network); and step 3 included individual characteristics (age, gender, education, living arrangement, participation in the labor force, and subjective health).

Multiple linear regression analyses for positive affect (see Table 3) revealed that ICT use significantly predicted positive affect in very old age, $F(2, 2171) = 15.00, p < .001$, adjusted $R^2 = .01$. Compared to individuals who used internet-based ICT, those who did not use any ICT ($\beta = -.12, p < .001$) and those who used offline ICT ($\beta = -.05, p = .026$) reported significantly lower levels of positive affect. After controlling for social inclusion variables and individual characteristics (Model 3), only the difference between non-users and online ICT users remained significant ($\beta = -.07, p = .002$). Conversely, the difference between offline and online users was no longer significant ($\beta = .00, p = .882$). RWA revealed that the most important predictors of well-being were frequency of social contact (RW = 40.2% proportional contribution to the total explained variance), general health (RW = 23.0%), and network size (RW = 16.2%). The contrast between no ICT use and online ICT use accounted for 6.6% of the explained variance.

ICT use also significantly predicted loneliness, $F(2, 2171) = 7.99, p < .001$, adjusted $R^2 = .01$ (see Table 4). Participants who did not use ICT ($\beta = .06, p = .005$) or used ICT without internet access ($\beta = .07, p < .001$) reported higher loneliness than those who used internet-based ICT. Both effects remained significant (no ICT: $\beta = .043, p = .043$; offline ICT: $\beta = .06, p = .011$) after adjusting for indicators of social inclusion (Model 2). However, when individual characteristics were added to the regression model (Model 3), both associations became non-significant ($.844 < p < .871$). RWA identified frequency of social contact (RW = 25.9%), gender (RW = 19.9%), and general health (RW = 18.7%) as the strongest predictors of loneliness.

ICT use significantly predicted perceived anomie, $F(2, 2171) = 23.42, p < .001$, adjusted $R^2 = .02$ (see Table 5). Compared to online ICT users, individuals who did not use ICT ($\beta = .13, p < .001$) and those who used offline ICT ($\beta = .09, p < .001$) reported higher levels of anomie. These effects remained significant even after adjusting for all control variables in Model 3 (no ICT: $\beta = .09, p < .001$; offline ICT: $\beta = .06, p = .009$). According to RWA, general health (RW = 38.1%), nonuse of ICT (compared to online use; RW = 19.9%), and frequency of social contact (RW = 9.6%) were the strongest predictors of anomie.

Table 3. Linear regression analyses to predict positive affect.

	<i>b</i> (<i>SE</i>)	β	<i>p</i>
Model 1: ICT only			
No ICT ^a	-.27 (.05)	-.12	<.001
Offline ICT ^a	-.07 (.03)	-.05	.026
Model fit	$F(2, 2171) = 15.00, p < .001, \text{adjusted } R^2 = .01$		
Model 2: indicators of social inclusion as covariates			
No ICT ^a	-.19 (.05)	-.08	<.001
Offline ICT ^a	-.03 (.03)	-.02	.316
Model fit	$F(6, 2167) = 47.01, p < .001, \text{adjusted } R^2 = .11$		
Model 3: indicators of social inclusion and individual characteristics as covariates			
No ICT ^a	-.15 (.05)	-.07	.002
Offline ICT ^a	.00 (.03)	.00	.882
Model fit	$F(13, 2160) = 28.32, p < .001, \text{adjusted } R^2 = .14$		

Note. ^a = online ICT use as reference group; ICT = Information and communication technologies; *b* = unstandardized regression coefficients; *SE* = standard errors; β = standardized regression coefficients; model 2 includes as covariates the number of persons in personal network, frequency of time with other people, frequency of participation in social activities, and received social support; model 3 additionally includes as covariates gender (ref. female), age, educational (ref. low level), long-term care (ref. private home), participation in the labor force (ref. never employed), and subjective health.

Table 4. Linear regression analyses to predict loneliness.

	<i>b</i> (SE)	β	<i>p</i>
Model 1: ICT only			
No ICT ^a	.14 (.05)	.06	.005
Offline ICT ^a	.11 (.03)	.07	<.001
Model fit	$F(2, 2171) = 7.99, p < .001, \text{adjusted } R^2 = .01$		
Model 2: indicators of social inclusion as covariates			
No ICT ^a	.10 (.05)	.04	.043
Offline ICT ^a	.08 (.03)	.06	.011
Model fit	$F(6, 2167) = 25.05, p < .001, \text{adjusted } R^2 = .06$		
Model 3: indicators of social inclusion and individual characteristics as covariates			
No ICT ^a	.01 (.05)	.00	.871
Offline ICT ^a	-.01 (.03)	.00	.844
Model fit	$F(13, 2160) = 26.41, p < .001, \text{adjusted } R^2 = .13$		

Note. ^a = online ICT use as reference group; ICT = Information and communication technologies; *b* = unstandardized regression coefficients; SE = standard errors; β = standardized regression coefficients; model 2 includes as covariates the number of persons in personal network, frequency of time with other people, frequency of participation in social activities, and received social support; model 3 additionally includes as covariates gender (ref. female), age, educational (ref. low level), long-term care (ref. private home), participation in the labor force (ref. never employed), and subjective health.

Table 5. Linear regression analyses to predict anomie.

	<i>b</i> (SE)	β	<i>p</i>
Model 1: ICT only			
No ICT ^a	.37 (.06)	.13	<.001
Offline ICT ^a	.16 (.04)	.09	<.001
Model fit	$F(2, 2171) = 23.42, p < .001, \text{adjusted } R^2 = .02$		
Model 2: indicators of social inclusion as covariates			
No ICT ^a	.35 (.06)	.13	<.001
Offline ICT ^a	.15 (.04)	.09	<.001
Model fit	$F(6, 2167) = 13.36, p < .001, \text{adjusted } R^2 = .03$		
Model 3: indicators of social inclusion and individual characteristics as covariates			
No ICT ^a	.26 (.06)	.09	<.001
Offline ICT ^a	.10 (.04)	.06	.009
Model fit	$F(13, 2160) = 12.24, p < .001, \text{adjusted } R^2 = .06$		

Note. ^a = online ICT use as reference group; ICT = Information and communication technologies; *b* = unstandardized regression coefficients; SE = standard errors; β = standardized regression coefficients; model 2 includes as covariates the number of persons in personal network, frequency of time with other people, frequency of participation in social activities, and received social support; model 3 additionally includes as covariates gender (ref. female), age, educational (ref. low level), long-term care (ref. private home), participation in the labor force (ref. never employed), and subjective health.

Internet use by purpose

Additional explorative analyses were conducted to examine internet use by purpose. Among ‘onliners’ (i.e., only those participants who used the internet), 23.3% reported using the internet exclusively for social purposes when compared to those who used it for both instrumental and other purposes. Conversely, 9.0% of onliners reported using the internet exclusively for instrumental purposes when compared to those who used it for both social and other purposes. These descriptive findings suggest that social internet use may have been more common than instrumental internet use within the sample. To test whether this difference in frequency was statistically significant, a McNemar test was conducted, revealing a significant difference ($p < .001$), with social internet use ($n = 831$) being reported more frequently than instrumental internet use ($n = 701$).

However, 67.7% of those who used the internet reported both types of use, indicating that the majority of the participants engaged in the internet for multiple reasons. In line with this observation, 72.1% of internet users reported using the internet for more than one of the four specific applications assessed in the study (i.e., sending or receiving e-mails, participating in social networks, searching for health-related information, and buying or selling goods or services).

Discussion

This study examined the relationship between different types of ICT use and three indicators of subjective well-being – positive affect, loneliness, and anomie – among the oldest-old (aged 80 and above) in Germany. Drawing on a nationally representative dataset, the findings provide insights into how digital engagement may contribute to subjective well-being in very late life. These results expand on previous findings by Schlomann, Seifert, Zank, Woopen, et al. (2020), who studied similar associations in a regional sample (NRW80+ survey).

Online ICT use as a resource for promoting well-being in very late life

Consistent with prior research (e.g., Lee, 2024; Schlomann, Seifert, Zank, Woopen, et al., 2020), internet-based ICT use was positively associated with dimensions of subjective well-being. Very old adults who used online ICT reported higher levels of positive affect than those who either used offline ICT or did not use ICT at all. The difference between online ICT use and no use remained significant even after accounting for indicators of social inclusion and individual characteristics, suggesting that online ICT use may offer benefits beyond facilitating social contact. These findings reinforce arguments that digital technologies may serve as meaningful psychological resources for older adults (Hülür & Macdonald, 2020; Sims et al., 2017). Notably, the relative weights analysis (RWA) conducted in this study showed that while online ICT use contributed to explaining variance in positive affect, frequency of contact with others, subjective health, and network size were even more influential in this regard. This highlights the relevance of offline social and health resources in shaping well-being outcomes and suggests that ICT use may complement, but not replace, these resources.

The results regarding loneliness paint a complex picture. While bivariate analyses indicated that both non-users and offline ICT users reported higher levels of loneliness than online ICT users, these associations diminished and became statistically nonsignificant once all covariates were included in the regression models. This contrasts with previous findings (e.g., Forsman et al., 2018; Schlomann, Seifert, Zank, Woopen, et al., 2020). One potential explanation for this is that loneliness in very old age is more directly shaped by the quantity and quality of interpersonal relationships than by digital engagement. Moreover, the RWA indicated that contact frequency, gender, and general health were the strongest predictors of loneliness. It is also plausible that only specific types of ICT-mediated communication or social media use (e.g., Cotten et al., 2022; Nowland et al., 2018; Rennoch et al., 2023) have protective effects against loneliness – a distinction not captured in the current study.

The study's analysis of perceived anomie yielded a particularly novel finding. This study demonstrated that both non-users of ICT and offline ICT users experienced significantly higher levels of anomie compared to online ICT users even after adjusting for social and individual variables. These results align with the findings of Schlomann, Seifert, Zank, Woopen, et al. (2020) for a regional sample and extend previous research by highlighting digital inclusion as a potential buffer against societal disconnection in very late life. As anomie involves feelings of alienation from societal values and rapid cultural change, online ICT use may offer a critical means of remaining oriented toward, informed of, and connected to contemporary life. Thus, ICT use may help older individuals feel more oriented and integrated by providing access to current information, media, and modes of communication that are central to modern society.

When taken together, the study's results suggest that digital engagement may provide meaningful benefits for the oldest-old and underscore the potential of internet-based ICT use to support subjective well-being and reduce feelings of societal disconnection. These benefits may arise from greater access to social resources, an enhanced sense of control, or increased opportunities for daily functioning, which are particularly relevant considering age-related limitations (Hülür & Macdonald, 2020; Sims et al., 2017). Our findings are also in line with those of Lee (2024), who found a positive association between internet use and life satisfaction. Given the increasing relevance of digital tools in everyday life, these benefits could become particularly important for maintaining quality of life for the oldest-old.

Patterns and purposes of internet use among the oldest-old

Overall, the proportion of internet users in this study was comparatively high relative to previous research. For example, Schlomann, Seifert, Zank, Woopen, et al. (2020) reported that 25.9% of the oldest-old used ICT with internet access, whereas 58.6% of participants in the present study reported ICT use with internet access. While this may reflect a genuine increase in internet use among the oldest-old over time – as documented, for example, by Huxhold et al. (2020) in a study using 2002–2014 data on older adults – sampling biases cannot be ruled out. The reliance on personal communication due to the COVID-19 pandemic may have systematically excluded less technologically savvy individuals. This may have introduced selectivity effects, leading to an overrepresentation of ICT users in the sample compared to the general population.

The subgroup of participants living in nursing homes constitutes a noteworthy example of such potential selectivity. In our sample, all institutionalized respondents reported using ICT in some form. This pattern is unlikely to be representative of the general population of institutionalized oldest-old, where overall ICT use is typically much lower (e.g., Schlomann, Seifert, Zank, & Rietz, 2020). It is plausible that the study's telephone-based survey may have excluded residents with more severe health impairments, cognitive decline, or limited technological access. At the same time, this finding underscores the potential relevance of ICT in institutional care contexts. Both online and offline technologies may play an important role in maintaining social ties and supporting daily functioning, especially in cases in which mobility and in-person contact are restricted. Therefore, future research should more systematically examine ICT use in institutional settings and consider both digital and non-digital tools and the conditions under which they may enhance well-being.

The comparatively high overall share of internet users in our study provided the opportunity to move past a simple user-versus-nonuser distinction and to examine different purposes of internet use among the oldest-old. Therefore, the analyses in this paper sought to examine different purposes of internet use to generate hypotheses for future research. The work's descriptive findings suggest that the oldest-old tend to use the internet more for social than for instrumental purposes. This aligns with socioemotional selectivity theory (Carstensen et al., 1999), which posits that very old adults prioritize socially meaningful goals, implying that social internet use may be particularly important for this age group. Previous studies have also indicated that social ICT use may be more strongly related to well-being among the oldest-old than instrumental use (Rennoch et al., 2023; Soundararajan et al., 2023). At the same time, most of the internet users in our sample reported using the internet for both social and instrumental purposes, suggesting that both domains may be relevant. When considered from a life-span developmental perspective, instrumental internet use may play a compensatory role in helping older adults maintain autonomy in everyday life by substituting offline activities that may no longer be feasible for them (Sims et al., 2017). These findings underscore the need for further studies to disentangle the role of different types of internet use for well-being in very late life.

Addressing the digital divide

Although many older adults use and benefit from digital technologies, a significant proportion of these adults lack digital proficiency, contributing to a digital divide that may exacerbate social exclusion and digital inequality. While technology can support social connectedness, older individuals with limited digital skills often experience exclusion and, to a certain extent, lower well-being. Technological innovation is advancing rapidly, yet research into its societal and individual-level effects remains in its early stages. A more robust collaboration between technology developers and academic researchers is essential for advancing our understanding of how individuals engage with ICT and for exploring the complex mechanisms through which ICT use influences various aspects of life.

Increased investment in education, training, and ongoing support is critical for promoting digital inclusion among older adults (Gallistl et al., 2020); however, when training is offered through

traditional educational institutions, it often fails to engage the individuals most affected by digital exclusion. Contemporary strategies increasingly rely on peer-to-peer models in which older adults receive training within a group setting and subsequently share their knowledge with peers who lack access to formal instruction.

Strengths and limitations

A major strength of this study lies in its use of a large, nationally representative dataset, which provides generalizable insights into the oldest-old population in Germany. The distinction between nonuse of ICT, offline ICT use, and online ICT use also enabled a fine-grained analysis of digital engagement. Additionally, the inclusion of multiple well-being indicators offers a comprehensive picture of psychological functioning in very late life.

This study has several limitations that must be acknowledged. First, its cross-sectional design precludes causal inference. Individuals with higher subjective well-being can plausibly be assumed to be likelier to engage with ICT than those with lower subjective well-being. Second, although the present study demonstrated significant associations between ICT use and well-being, the observed effect sizes were generally small. Given the theoretically plausible and empirically supported links between digital engagement and these outcomes, such marginal effect sizes may suggest that the operationalization of ICT use in this study was not sufficiently differentiated. A finer-grained measurement that includes, for example, the intensity and diversity of ICT activities as well as their specific purposes, may reveal stronger associations and provide a more nuanced understanding of how digital practices contribute to well-being in very late life. Finally, while the oldest-old represent a growing and highly relevant population segment, they remain underrepresented in digital behavior research, and further longitudinal studies are needed.

Conclusion

This study highlights the potential of internet-based ICT use as a valuable resource for individuals in very late life. The study's findings emphasize the importance of promoting digital engagement among the oldest-old through age-inclusive technologies, targeted training, and policy efforts aimed at narrowing the gray digital divide. Future research should focus on identifying the specific digital practices that are most beneficial in this regard and how they can be adapted to effectively support the needs of this rapidly growing population segment.

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Author contributions

CRedit: **Anna Schlomann:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Software, Visualization, Writing – original draft, Writing – review & editing; **Alexander Seifert:** Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing; **Christian Rietz:** Supervision, Validation, Writing – review & editing.

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Data availability statement

The raw data supporting this article's conclusions are available from "Deutsches Zentrum für Altersfragen" (DZA) for use in non-commercial research using the application form at <https://www.dza.de/en/research/fdz/access-to-data/application>.

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