RCPHN
Research in Community and Public Health Nursing

Original Article

pISSN 2983-0648 · eISSN 2288-4203
Res Community Public Health Nurs 2024;35(4):389-400
https://doi.org/10.12799/rcphn.2024.00766

Digital Health Literacy and Associated Factors Among Older Adults Living Alone in South Korea: A Cross-Sectional Study

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Purpose: This study aimed to examine the level of digital health literacy and identify factors associated with digital health literacy among older adults living alone in South Korea.
Methods: A cross-sectional study was conducted on 140 older adults aged 65 and above who live alone. Descriptive statistics and non-parametric methods were used to explore the relationship between digital health literacy and independent variables. A generalized linear model was used to identify factors associated with digital health literacy.
Results: Among 140 smartphone-owning older adults living alone, 52.1% were using the Internet via digital devices, and the participants' average digital health literacy score was 6.64±7.46. Univariate analysis results showed significant differences in digital health literacy according to age, education level, and multimorbidity. The factors associated with digital health literacy were identified as gender (B=−0.36, p=.031), age (B=−0.06, p<.001), education level (B=0.12, p<.001), and sleep problems (B=−0.06, p=.006).
Conclusion: Despite widespread Internet and smartphone use, older adults living alone with chronic diseases showed low levels of digital health literacy, which were significantly associated with gender, age, education level, and sleep problems. Enhancing digital health literacy among vulnerable populations is crucial for the effective implementation of digital health services. Collaborative efforts, including tailored digital health interventions to enhance the digital health literacy of vulnerable populations and supportive policies, are essential to bridge the digital divide and promote health equity.

Keywords: Health literacy; Digital health; Digital divide; Aged

Introduction

With the world's population rapidly aging, the proportion of individuals aged 65 years and older is expected to increase from approximately 10% of the global population by 2022 to nearly 12% by 2030 and 16% by 2050 [1]. This rapid demographic shift presents significant health challenges and socioeconomic burdens. Longer life expectancies lead to an increased susceptibility to noncommunicable diseases, including cardiovascular diseases, cancer, chronic respiratory diseases, diabetes, and kidney diseases, necessitating lifelong monitoring and management [2]. The number of older adults living alone has increased in developed countries. In the U.S. and Europe, approximately 27–28% of people aged 60 years and older live alone [3], and this trend is expected to continue as baby boomers age [4]. In South Korea, the proportion of older adults residing in single-person households is projected to significantly increase in line with the country's rapidly aging rate, from 36.1% in 2022 to 41.1% in 2050 [5]. Older adults living alone face various risks, including impaired health, difficulties in performing daily activities, poor memory and emotional state, decreased physical activity, malnutrition, heightened healthcare utilization, and social isolation

Received: August 28, 2024; **Revised:** October 15, 2024; **Accepted:** November 19, 2024
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[6-10]. Living alone in later life is associated with a reduced quality of life, negative health outcomes, and increased mortality [11-13]. Furthermore, this situation can lead to higher healthcare expenditures and a greater social burden.

Digital technology offers the potential to effectively address the healthcare needs of the older population and improve healthcare efficiency [14]. Implementing digital health technologies allows for delivering healthcare services to a broader population at a reduced cost while enhancing patient engagement. This approach addresses the limitations of physical distance and accessibility inherent in conventional healthcare services [15]. However, the adoption of digital technology in healthcare can exacerbate health inequalities if issues related to accessibility and affordability for vulnerable groups are not adequately addressed [16]. The expansion of digital technology has been accelerated by the physical distancing and infectious disease prevention measures necessitated by the Coronavirus Disease 2019 (COVID-19) pandemic [17]. This rapid digital transformation has widened the digital divide between those with access to digital technology and those without. Older adults are particularly vulnerable to this divide, as they face higher risks of contracting COVID-19 and experiencing limited access to healthcare services due to barriers in using digital technology [18,19]. Compared to other age groups, older adults are less likely to acquire high-quality information or utilize online platforms for essential services, and they are more likely to suffer from social isolation and loneliness, which pose significant health threats [20]. Although the use of telemedicine, online video conferencing platforms, and social media usage have surged during the COVID-19 pandemic [17], the rapid adoption of these technologies has exacerbated inequalities among those less familiar with digital tools. Older adults with vulnerable social determinants of health, such as older age, less education, low income, and specific geographical location, require more support in using digital technology due to the considerable gap between their digital skills and healthcare needs [14].

Digital health literacy is the ability to use digital technologies to find, understand, and evaluate health information, translate it into knowledge appropriate to an individual's context, and apply it to solve health problems or improve health and quality of life [21-24]. The term is often used interchangeably with eHealth literacy; however, it encompasses a broader scope within the context of technology, including mobile health, health information technology (IT), telemedicine, wearable devices, and personalized medicine. [25,26]. To date, research on digital health literacy has predominantly utilized the eHealth Literacy Scale (eHEALS) and has focused on the determinants of digital health literacy and its relationship with health outcomes in specific populations or the general adult population [27-31]. Previous studies have shown that age, education, income, and daily Internet use are positively associated with digital health literacy [32-34]. Individuals living alone or with limited social support tend to have lower digital health literacy [27,31]. Digital health literacy is positively correlated with health behaviors [35] and significantly impacts the quality of life [36]. Digital health literacy and Internet connectivity are considered a super social determinant of health [37]. This is because it can shape both the social determinants of health and nonmedical factors that determine a person's health, including housing, education, income, and access to affordable health services. Given the potential health benefits associated with improved digital health literacy, it is essential to identify populations with low digital health literacy and determine the association between digital health literacy and their characteristics [38].

Recent studies have explored digital health literacy among older adults, who are considered particularly vulnerable in the digital age [31,39]. However, many of these studies considered eHealth literacy to be the same as digital health literacy and mainly used the eHEALS [28]. eHealth literacy primarily focuses on the search for and use of health information on the internet and online platforms [40]. Digital health literacy, however, emphasizes the ability to manage and utilize health information not only through the Internet but also across various digital platforms and tools. Therefore, digital health literacy can be seen as a broader concept than eHealth literacy, and it is becoming increasingly important with the advancement of digital technologies [25]. Moreover, even within studies focusing on older adults, findings on the level of digital health literacy and its predictors have been inconsistent, varying based on the sociodemographic, digital-related, and health-related characteristics of the study participants [29,32,41]. Thus, this study aimed to examine the level of digital health literacy and identify factors associated with digital health literacy among older adults living alone in South Korea. This approach will facilitate the development of tailored interventions to enhance digital health literacy, thereby contributing to health equity.

Methods

Study design

This study is a cross-sectional descriptive study to identify digital health literacy and associated factors among older adults liv-

ing alone.

Participants

The participants in this study were community-dwelling older adults aged ≥ 65 years. Inclusion criteria were 1) currently living alone with no family or relatives living with them, 2) smartphone ownership, 3) physician diagnosis of at least one chronic disease, and 4) no severe cognitive impairment (excluding a Mini-Mental State Examination (MMSE) score of 17 or less). The Digital Health Technology Literacy-Assessment Questionnaire (DHTL-AQ) used in this study was validated with smartphone-owning adults [25], which is why smartphone ownership was included as a criterion for participant selection. The minimum sample size required for multiple regression analysis was calculated using version 3.1.9.7 of G*power [42]. Based on the adjusted R^2 values (0.12 to 0.14) reported in previous studies that examined factors influencing eHealth literacy [32,39], a medium effect size was derived ($f^2 = R^2/(1-R^2)$) [43]. A minimum of 135 participants was required for a power of 0.8 for a two-tailed test with a significance level of $\alpha = .05$, medium effect size ($f^2 = 0.15$), and 14 independent variables. Considering the prevalence of dementia of 10.33% among Korean older adults [44] and the smartphone penetration rate of older adults of 80% [45], we aimed to recruit 192 older adults living alone with a dropout rate of 30%. Of the 191 individuals who agreed to participate in the study, 51 were excluded. The reasons for excluding the 51 participants were as follows: three participants with MMSE scores below 18, one participant with no chronic conditions, one participant with limited communication owing to hearing impairment, and 46 participants did not own a smartphone. In total, 140 participants completed the survey.

Measures

1. Sociodemographic characteristics

Sociodemographic characteristics, such as age, gender, education level, surviving children, and economic status, were assessed.

2. Digital-related characteristics

Digital-related characteristics were assessed using four items from the 2020 Digital Divide survey [45]. These items included whether participants owned a desktop computer (yes/no), laptop (yes/no), tablet PC (yes/no), and whether they had experience using the Internet (yes/no).

3. Health-related characteristics

Health-related characteristics included multimorbidity, perceived health status, sleep problems, stress, communication with physicians, and self-efficacy. Perceived health status was measured using the Korean version of the scale developed by Speake and Cowart [46]. This scale consists of three items rated on a 5-point Likert scale (poor = 1 to excellent = 5), including current overall health status, health status compared with peers, and health status compared with one year ago. Higher total scores indicate better-perceived health status. The Cronbach's α of the Korean version of the scale was .88 [47], while in this study, the Cronbach's α was .73. Sleep problems and stress were assessed using a 10-point visual numerical scale ranging from 0 to 10 [48]. Higher scores indicate more sleep problems or increased stress. Communication with physicians was measured using the Self-Management Resource Center Scale [49]. It consists of three items ranging from 0 to 5 points. The score is the mean of the three items, with a higher score indicating better communication with the physicians. In the study by Lorig et al. [49], the reliability was reported as Cronbach's α = .73, whereas in the present study, the reliability was Cronbach's α = .71. The six-item Self-Efficacy for Managing Chronic Disease 6-item Scale was used to assess the self-efficacy of the participants [49]. This measure consists of six items rated on a 10-point Likert scale. The score for the scale is the mean of six items. Higher scores indicated higher self-efficacy in managing chronic diseases. Cronbach's α was .91 in Lorig et al.'s study [49], and the reliability of the scale was satisfactory in the present study (Cronbach's α = .90).

4. Digital health literacy

Digital health literacy was measured using the DHTL-AQ [25]. This scale consists of 34 dichotomous scale items across two domains (digital functional and digital critical literacy) and four categories (Information and Communications Technology (ICT) terms, ICT icons, use of an app, and evaluation of the reliability and relevance of health information). A higher score indicates a greater level of digital health technology literacy. Participants were categorized into high/low groups based on a cutoff score of 22. This cutoff score was derived during the development of the DHTL-AQ through receiver operating characteristic (ROC) analysis. It was set at the point where the sum of sensitivity and specificity was maximized (sensitivity 86.4%, specificity 86.4%) [25]. Cronbach's α coefficients were calculated at .95 by Yoon et al., who also reported an acceptable model fit (CFI = 0.821, TLI = 0.807, SRMR = 0.065, RMSEA = 0.090). The DHTL-AQ was moderately correlated with the eHEALS (r = .53) and the Newest Vital Sign (r = .59) [25]. The reliability of the scale in the present study was also satisfactory (Cronbach's α = .94).

Data collection

This study was conducted in South Korea between August 10 and August 13, 2021. The participants were recruited through convenience sampling in Siheung City, South Korea. We collaborated with the public health centers of Siheung City to distribute participant recruitment materials at the public health, community, and welfare centers. Before completing the survey, the participants underwent a face-to-face interview with a trained research assistant to ensure eligibility. All research assistants were trained in the purpose, content of the study, physical examination, and survey methods before administering the survey. The face-to-face interviews took about one hour, and the participants who completed all the surveys received a small gift in return.

Ethical considerations

This study complied with the principles of the Declaration of Helsinki and was approved by the Institutional Review Board of the corresponding author's institution (IRB No. 2106/003-011). After the purpose and processes of the study were explained, written informed consent was obtained from all the participants.

Data analysis

Data were analyzed using SPSS software (version 26.0; SPSS Inc., Chicago, IL, USA). To analyze the sociodemographic, digital-, and health-related characteristics of the participants, frequency, percentage, mean, and standard deviation were calculated. Nonparametric methods were applied since the dependent variable (digital health literacy) was not normally distributed. The Chi-square test, Mann-Whitney U test, Kruskal-Wallis test, and independent t-test were performed to assess differences in internet usage and digital health literacy based on participant characteristics. Dunn's post hoc tests were conducted, with the significance level adjusted using the modified Bonferroni method. Additionally, Spearman's rank correlation coefficient was used to examine the relationships between digital health literacy and continuous variables, including cognitive function, sleep problems, stress, perceived health status, self-efficacy, and communication with physicians. Furthermore, a generalized linear model was used to identify factors associated with digital health literacy. Since the dependent variable exhibited a right-skewed distribution, including values of 0, a gamma model was selected after performing a variable transformation by adding 1 to all dependent variable values. In all analyses, $p < .05$ was considered statistically significant.

Results

Sociodemographic, digital, and health-related characteristics and digital health literacy

Of the 140 older adults, 99 (70.7%) were women, and 81 (57.9) were aged 75–84. Their mean age was 76.26 ± 4.67 years (range 66 to 86). More than half (86/140, 61.5%) had an elementary school education or less, and most had children (125/140, 89.3%). Of the participants, 73 people (52.1%) had experience using the Internet. Two-thirds (93/140, 66.4%) had 3 or more chronic diseases. The study participants' characteristics that showed significant differences based on Internet usage included age ($\chi^2 = 8.28$, $p = .014$), education level ($\chi^2 = 21.45$, $p < .001$), cognitive function ($Z = -2.81$, $p = .005$), multimorbidity ($\chi^2 = 8.46$, $p = .015$), self-efficacy ($Z = -2.77$, $p = .006$), and digital health literacy ($Z = -6.73$, $p < .001$) (Table 1).

The participants' mean digital health literacy score was 6.64 ± 7.46, significantly lower than the cut-off score of 22. Among the subcategories, 'evaluating reliability and relevance of health information' had the lowest average score, while 'use of an app' had the highest average score. Except for 4 participants, the majority had low digital health literacy (Table 2).

Factors associated with digital health literacy

The univariate analysis results presented in Table 3 indicate significant differences in digital health literacy based on age, education level, and multiple morbidities. After a post hoc test, those aged 65–74 had higher digital health literacy scores than those aged 75–84 years. Participants with a high school education had higher digital health literacy scores than those with a middle school or lower education. Older adults living alone with 1 chronic condition scored higher on digital health literacy than those with 3 or more conditions (Table 3).

The Spearman correlation coefficients between digital health literacy and the continuous variables are shown in Table 4. The results showed that the cognitive function ($\rho = .29$, $p = .001$), perceived health status ($\rho = .26$, $p = .002$), and self-efficacy ($\rho = .28$, $p = .001$) had weak positive correlations with digital health literacy. In addition, a weak negative correlation was found between sleep problems ($\rho = -.24$, $p = .001$) and digital health literacy (Table 4).

The generalized linear model analysis revealed factors associated with higher digital health literacy among older adults living alone as women ($B = -0.36$, $p = .031$), younger ($B = -0.06$, $p < .001$), having a higher education level ($B = 0.12$, $p < .001$), and having fewer sleep problems ($B = -0.06$, $p = .006$) (Table 5).

Table 1. Participants' Sociodemographic, Digital-, and Health-Related Characteristics (*N*=140)

Variables	Categories	n (%) or M ± SD
Gender	Men	41 (29.3)
	Women	99 (70.7)
Age (year)	65-74	52 (37.1)
	75-84	81 (57.9)
	≥ 85	7 (5.0)
Education level	Uneducated	12 (8.6)
	Elementary school	74 (52.9)
	Middle school	25 (17.9)
	High school	26 (18.6)
	≥ University	3 (2.1)
Surviving children (person)	≥ 1	125 (89.3)
	None	15 (10.7)
Economic status	More than medium	88 (62.9)
	Low	52 (37.1)
Ownership of digital devices		
Desktop computer	Yes	19 (13.6)
	No	121 (86.4)
Laptop	Yes	8 (5.7)
	No	132 (94.3)
Tablet PC	Yes	4 (2.9)
	No	136 (97.1)
Experiences using the Internet	Yes	73 (52.1)
	No	67 (47.9)
Multimorbidity	1	15 (10.7)
	2	32 (22.9)
	≥ 3	93 (66.4)
Cognitive function (MMSE)		27.04 ± 2.42
Sleep problem		3.91 ± 3.03
Stress		3.70 ± 2.83
Perceived health status		8.72 ± 2.64
Communication with physicians		2.37 ± 1.58
Self-efficacy		6.49 ± 2.16

PC = personal computer; MMSE = mini-mental state examination.

Discussion

This study aimed to deepen the understanding of older adults' access to digital health technologies and the vulnerabilities associated with digital health literacy. To achieve this, the study identified the digital health literacy levels of older adults living alone and the factors associated with digital health literacy. Slightly more than half of these individuals own a smartphone but do not use the Internet, and despite owning a smartphone, their digital health literacy is generally reported to be low. The factors associated with digital health literacy identified in this study included gender, age, education level, and sleep problems.

In the present study, participants had a comparatively low Internet usage rate of 52.1%, which is significantly lower than the 64.4% usage rate for adults over 70 years in Korea [50] and 75% for adults over 65 years in the US [51]. The finding that Internet use varied significantly based on age, education level, and the number of chronic diseases aligns with previous studies examining factors influencing Internet use among older adults [31,39,52]. The Internet penetration rate in Korea is 99.97%, and the Internet usage rate among people in their 60s has increased from 89.1% to 94.9%, and among those in their 70s and older, it has risen from 38.9% to 64.4% [50]. However, the Internet usage rate among the participants in this study was reported to be relatively low. Possible explanations are that older adults living alone often have lower incomes, less access to the Internet and digital devices, and lack the social resources needed to learn and use new digital technologies compared to those who do not live alone [53-55]. Internet use can positively impact older adults living alone by strengthening their social capital, which can increase the benefits of Internet use and improve life satisfaction [54,55]. However, if consideration and support are not provided in advance for the older population with vulnerable sociodemo-

Table 2. Participants' Level of Digital Health Literacy (*N*=140)

Variables	Categories	M ± SD	Min	Max	Possible Range
Digital health literacy	Total	6.64 ± 7.46	0	32	0–34
	ICT terms	1.52 ± 2.35	0	9	0–11
	ICT icons	1.70 ± 2.29	0	9	0–9
	Use of an app	2.26 ± 2.78	0	9	0–9
	Evaluating reliability and relevance of health information	1.16 ± 1.77	0	5	0–5
	Low (n = 136)	6.01 ± 6.57	0	21	0–21
	High (n = 4)	28.00 ± 3.16	25	32	22–34

ICT = information and communication technology.

Table 3. Differences in Digital Health Literacy by Participants' Characteristics (*N*=140)

Characteristics		Digital Health Literacy	
		M ± SD	Z or H (*p*)
Gender	Men (n = 41)	7.05 ± 7.28	−0.65 (.517)
	Women (n = 99)	6.47 ± 7.56	
Age (years)	65–74 (n = 52) [a]	8.81 ± 7.46	12.54 (.002) [†]
	75–84 (n = 82) [b]	5.47 ± 7.19	a > b
	≥ 85 (n = 7) [c]	4.14 ± 7.73	
Education level	Uneducated (n = 12) [a]	3.17 ± 5.54	40.28 (< .001) [†]
	Elementary school (n = 74) [b]	3.78 ± 4.67	d > a, b, c
	Middle school (n = 25) [c]	7.08 ± 6.49	
	High school (n = 26) [d]	15.54 ± 8.65	
	≥ University (n = 3) [e]	10.33 ± 6.03	
Surviving children	≥ 1 (n = 125)	6.39 ± 7.43	−1.21 (.227)
	None (n = 15)	8.73 ± 7.61	
Economic status	More than medium (n = 88)	6.48 ± 7.15	−0.38 (.706)
	Low (n = 52)	6.92 ± 8.02	
Multimorbidity	1 (n = 15) [a]	13.47 ± 9.59	12.33 (.002) [†]
	2 (n = 32) [b]	7.28 ± 7.16	a > c
	≥ 3 (n = 93) [c]	5.32 ± 6.58	

[†]Kruskal-Wallis H test.

Table 4. Correlations Between Continuous Variables and Digital Health Literacy (*N*=140)

Variables	ρ (*p*)
Cognitive function (MMSE)	.29 (.001)
Sleep problem	-.24 (.005)
Stress	-.12 (.163)
Perceived health status	.26 (.002)
Self-efficacy	.28 (.001)
Communication with physicians	.17 (.051)

MMSE = mini-mental state examination.

graphic factors, digital exclusion may lead to social exclusion, thereby exacerbating health and social inequality. This implies a strong need to reduce barriers for vulnerable groups to accessing digital technologies. This could include supporting broadband for low-income households, expanding public Wi-Fi networks with stable and always-on access, and offering affordable digital devices [56].

The characteristics of the participants were associated with low digital health literacy among older adults living alone. Compared to previous studies on eHealth literacy and associated factors, the participants in this study were relatively older and less educated, with a mean age of 76.26 ± 4.67 and a mean of 7.14 ± 3.83 years of education. This study found that digital health literacy decreased with age, which is consistent with the results of studies on eHealth literacy and associated factors [32,57] and digital health literacy and its determinants [33]. However, in these studies, the mean age of the participants ranged from 70.93 to 74.2 years old, which was lower than the age of the participants in this study [32,33,57]. More than half of the participants (61.4%) in this study had an elementary school education or less. Education level appears to have a stronger effect on eHealth literacy than age. A study by Lee and Kim found that eHealth literacy among American and Korean older adults in similar age groups increases with higher education levels [32]. Additionally, no significant difference in eHealth literacy was observed between young and old adults with comparable education levels [41]. These findings of previous studies suggest that the low education level of the participants in this study is closely related to their low digital health literacy. Previous studies investigating factors related to eHealth literacy have identified that living alone and a lack of social support are associated with lower levels of digital health literacy, which is consistent with the findings of this study [31,58-60]. In some studies, multivariate analysis results showed that living alone did not significantly affect eHealth literacy; however, univariate analysis reported significant differences in eHealth literacy depending on living arrangements [31,58,60]. This suggests that living alone could potentially affect digital health literacy, depending on a combination of an individual's surroundings and intrinsic characteristics. Therefore, further studies are need-

Table 5. Generalized Linear Model for Factors Associated with Digital Health Literacy (N=140)

Variables	B	SE	Wald	p
(Constant)	4.83	1.54	9.82	0.002
Gender (men)	−0.36	0.17	4.64	0.031
Age	−0.06	.014	17.56	< .001
Education level	0.12	0.12	40.72	< .001
Cognitive function (MMSE)	0.03	0.03	1.14	0.285
Multimorbidity	−0.04	0.03	2.54	0.111
Sleep problem	−0.06	0.02	7.56	0.006
Perceived health status	0.01	0.03	0.17	0.683
Self-efficacy	0.03	0.04	0.71	0.399
	χ^2 = 81.96 (p < .001) LL = −383.35, deviance/df = 0.66			

MMSE = mini-mental state examination.

ed to explore the relationship between the combination of the physical environment and intrinsic characteristics of digitally vulnerable groups and digital health literacy.

In addition, the difference between the digital health literacy instrument used in this study and eHEALS, commonly used in previous studies, may have contributed to the lower reported digital health literacy among older adults living alone. The eHEALS is a widely used self-report scale that measures eHealth literacy in computer and Internet environments [61]. Although this tool has been extensively studied and validated, it has inherent limitations in measuring the characteristics of digital health literacy, a broader concept than eHealth literacy regarding the context of digital technologies [25,61]. It was not possible to measure the ability to communicate with health information using digital technology or the ability to find and use health information in a mobile environment. In addition, eHEALS is a self-reported tool that measures the level of eHealth literacy based on the respondent's perceptions [40]. Thus, there is a possibility that respondents may overestimate their level compared to the actual level [62]. Although the DHTL-AQ used in this study is also a self-report instrument, it highly correlates with the actual performance skills of mobile application tasks [25]. This indicates a higher correlation than the moderate association between perceived and performed eHealth literacy found in Neter and Brainin's study [63]. It measures respondents' levels of digital health literacy through questions about ICT terms and icons and the use of apps. Digital health literacy is evolving and demands competencies that differ from those required for eHealth literacy. Therefore, it is essential to understand the attributes of these concepts and develop an instrument that accurately measures a respondent's digital health literacy [28]. A reliable and valid digital health literacy instrument is needed to measure this critical construct effectively in clinical settings. Additionally, it should be convenient and automated to enhance usability [63].

We also found a negative association between sleep problems and digital health literacy. This supports a longitudinal study investigating the relationship between eHealth literacy and cardiac events in Iranian older adults with heart failure [64]. Lin et al. explored that the effect of eHealth literacy on reducing the likelihood of cardiac events was mediated through insomnia, psychological distress, and medication adherence [64]. Sleep deprivation significantly affects various cognitive domains, including attention, working memory, processing speed, short-term memory, and reasoning [65]. It is also associated with psychosocial health problems such as depression and anxiety [66]. The fact that sufficient sleep can enhance learning, memory, and creative problem-solving skills supports the findings of this study on the relationship between sleep problems and digital health literacy [67,68]. However, research directly exploring the relationship between sleep and digital health literacy is currently lacking, and further studies are needed to investigate the deeper connection between these variables.

Meanwhile, the findings regarding the relationship between gender and digital health literacy are inconsistent with those of previous studies [31,39,52]. This discrepancy may be because more than two-thirds of the participants were women, which could have influenced the results. This limitation is related to the use of convenience sampling in this study. Future research should explore factors related to digital health literacy using a more representative sample, achieved through stratified sampling based on demographic characteristics such as age and gender.

Bivariate analysis indicated significant correlations between digital health literacy and variables, including cognitive function, multimorbidity, self-efficacy, and perceived health status. How-

ever, the generalized linear model analysis did not identify these variables as factors associated with digital health literacy. This study's non-significant relationship between multimorbidity and digital health literacy aligns with earlier research on eHealth literacy among low-income, homebound older adults [31]. In contrast, this study found no significant association between perceived health status and digital health literacy, which differs from previous studies that reported a positive relationship between perceived health status and eHealth or digital health literacy [33,34]. This inconsistency may be attributable to differences in the sociodemographic and health-related characteristics of participants, such as living arrangements, age, and the number of chronic diseases, between this study and prior research. Although bivariate analysis showed a positive correlation between self-efficacy and digital health literacy, the generalized linear model did not find a significant association between these variables. Previous studies showed that self-efficacy acted as a mediator between eHealth literacy and chronic disease self-management [69], and eHealth literacy was a predictor of chronic disease self-management behaviors [69,70] and quality of life [36]. Further studies are needed to determine whether self-efficacy mediates the relationship between digital health literacy, chronic disease self-management behaviors, and quality of life among older adults living alone with chronic conditions.

This study has several limitations. First, the study included only older adults from one city through convenience sampling, which limits its generalizability. Further studies should focus on more representative samples, utilizing methods such as stratified sampling. Second, this was a cross-sectional descriptive study, and causality could not be determined. There is an urgent need to identify causal relationships between digital health literacy and associated factors through randomized controlled trial design. This will provide stakeholders with a basis for understanding the impact of digital health literacy on health and developing strategies to improve health equity.

Conclusions

Despite the high penetration rate of the Internet and smartphones, older adults living alone with chronic diseases demonstrated relatively low levels of digital health literacy. Gender, age, education level, and sleep problems were associated with their digital health literacy. Improving the digital health literacy of vulnerable populations, such as older adults living alone, is essential for the effective implementation of digital health services. To optimize these services, it is necessary to develop and evaluate digital health interventions tailored to the digital health literacy levels of the target population. Furthermore, collaborative efforts from governments, communities, and the private sector are essential to bridge the gap in digital health literacy and promote health equity, including the formulation of policies that support digitally vulnerable groups.

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Conflict of interest

The authors declared no conflict of interest.

Funding

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No.2021R1A2C2006222).

Authors' contributions

Minhwa Hwang contributed to data curation, formal analysis, visualization, writing - original draft, review & editing, investigation, software, and resources. Gahye Kim and Seonghyeon Lee contributed to data curation, writing - review & editing, investigation, resources, and validation. Yeon-Hwan Park contributed to conceptualization, funding acquisition, methodology, project administration, writing - review & editing, investigation, resources, supervision, and validation.

Data availability

Please contact the corresponding author for data availability.

Acknowledgments

None.

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