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Factors associated with willingness to participate in technology-mediated health and care support activities among older adult caregivers in the Los Ríos region, Chile: a cross-sectional study

Factores asociados a la disposición para participar en actividades de salud y apoyo al cuidado mediadas por tecnologías en personas mayores cuidadoras de la región de Los Ríos, Chile: un estudio transversal

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Palabras clave

Cuidadores; Adulto Mayor; Salud Digital; Teléfono Celular; Actitud hacia los Computadores.

Abstract

Introduction

Informal caregiving involves continuous, unpaid care and is associated with physical and emotional burden. Digital technologies could support caregivers; however, their use among older caregivers remains low.

Objective

To identify factors associated with the willingness of caregivers aged 60 years and older to participate in technology-mediated health and caregiving support activities.

Methods

A cross-sectional, descriptive-correlational study was conducted with 109 informal caregivers aged 60 years and older from the Los Ríos Region, Chile, recruited through convenience sampling. A questionnaire was administered to collect data on sociodemographic characteristics, caregiver burden (short version of the Zarit Burden Interview), access to and knowledge of technology, and beliefs regarding the usefulness of digital devices. Bivariate analyses and Firth's penalized logistic regression were performed.

Results

Overall, 37.6% of participants expressed willingness to participate. In the bivariate analysis, willingness to participate was associated with educational attainment, income, access to technology, knowledge of mobile phones, and favorable beliefs about the usefulness of mobile phones and computers. In the multivariable model, high mobile phone knowledge and favorable beliefs regarding the usefulness of mobile phones were associated with willingness to participate. Education, income, and internet access were not statistically significant in the adjusted model.

Conclusion

Self-reported knowledge of mobile phones and their perceived usefulness are associated with willingness to participate in technology-mediated support activities. Interventions should strengthen practical mobile phone skills. These findings are preliminary given the limited sample size.

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Conflict of interest

The authors declare no conflicts of interest.

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CRediT authorship contribution statement

A.P.C.U.: Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **V.D.M.**: Conceptualization, Investigation (data collection), Project administration, Writing - original draft, Writing - review & editing. **J.R.**: Methodology, Formal analysis, Writing - review & editing. **N.O.**: Investigation (data collection), Writing - review & editing. **G.G.**: Writing - original draft, Writing - review & editing. **R.B.**: Methodology, Data curation, Formal analysis, Supervision, Writing - review & editing. All authors read and approved the final version of the manuscript.

Data Availability

The data supporting the findings of this study are publicly available on Zenodo under the identifier https://doi.org/10.5281/zenodo.23509670

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Resumen

Introducción

El cuidado informal implica atención constante y no remunerada, con una carga física y emocional. Las tecnologías digitales podrían apoyar a los cuidadores, pero su uso entre los cuidadores mayores es bajo.

Objetivo

Identificar los factores asociados a la disposición de cuidadores de 60 años y más para participar en actividades de salud y apoyo al cuidado mediadas por tecnología.

Métodos

Estudio transversal, descriptivo-correlacional, con 109 cuidadores informales de 60 años o más de la región de Los Ríos, Chile, seleccionados por conveniencia. Se aplicó un cuestionario sobre características sociodemográficas, sobrecarga (Zarit abreviada), acceso y conocimiento tecnológico y creencias sobre la utilidad de los dispositivos. Se realizaron análisis bivariados y una regresión logística de Firth.

Resultados

El 37.6% manifestó disposición para participar. En el análisis bivariado, esta se asoció con la educación, el ingreso, el acceso a tecnologías, el conocimiento del teléfono y las creencias favorables sobre el teléfono y el computador. En el modelo multivariado, se asociaron el alto conocimiento del teléfono móvil y la creencia favorable sobre su utilidad. La educación, el ingreso y el internet no fueron significativos.

Conclusión

El conocimiento autorreportado sobre el teléfono móvil y la percepción de su utilidad se asocian con la disposición a participar. Las intervenciones deberían fortalecer las competencias prácticas en el uso del celular. Estos hallazgos son preliminares debido al tamaño limitado de la muestra.

Remark

1) Why was this study conducted?

This study aimed to identify the factors associated with the willingness of informal caregivers aged 60 years and older in the Los Ríos Region of Chile to participate in technology-mediated health and caregiving support activities. Given the potential of digital health technologies to support caregivers, as well as the barriers that older adults may face in adopting these tools, understanding the role of digital skills, perceived usefulness, and access to technology is essential to inform future interventions and digital inclusion strategies.

2) What were the most relevant results of the study?

Of the 109 caregivers surveyed, 37.6% expressed willingness to participate in technology-mediated health and caregiving support activities. In the bivariate analysis, we observed differences by educational level, income, access to the internet, mobile phones and computers, mobile phone knowledge, and beliefs about the usefulness of mobile phones and computers. None of the participants with low mobile phone access expressed willingness to participate. In the multivariable model (AUC= 0.88), only two factors remained independently associated. The first was high mobile phone knowledge (OR= 3.49; 95% CI: 1.10-12.78). The second, and the strongest, was a favorable belief in the usefulness of mobile phones for caregiving (OR= 7.66; 95% CI: 1.96-36.97). Educational level, income, and internet access were no longer significant after adjustment. This suggests that willingness depends more on mobile phone skills and perceptions than on access or socioeconomic conditions.

3) What do these results contribute?

These findings provide preliminary evidence to guide the development of digital inclusion strategies and technology-based caregiving support interventions tailored to the needs of older informal caregivers. They suggest that interventions should go beyond facilitating access to technology and prioritize practical training in mobile phone use, digital confidence, and recognition of the usefulness of mobile technologies for caregiving. These findings may inform future programs that bring together the health, education, and social services sectors. However, studies involving larger samples are needed to confirm the observed associations and support their generalizability.

Introduction

An informal caregiver is a person who, without receiving compensation, provides constant care to a dependent individual or family member. This work, while essential, entails a considerable physical and emotional burden that can affect the caregiver's health, well-being, and social life [1,2].

Technology in caregiving can take many forms: from communication tools (phones, video calls) to monitoring devices, health apps, and information platforms. Previous research has shown that the appropriate use of these tools can reduce the caregiver's burden, improve time management, and increase the safety of care [3].

In recent years, there has been growing interest in digital interventions designed to support informal caregivers, particularly those caring for people with dementia or disabilities. Recent reviews confirm that these interventions can significantly reduce depressive symptoms, anxiety, and perceived stress among caregivers [4,5]. For example, it has been reported that online programs are effective in reducing anxiety and increasing self-efficacy [4]. Similarly, other authors found that internet-based digital education reduces emotional distress related to the behavioral problems of the person being cared for [6].

On the other hand, various studies identify barriers to technology adoption, such as low levels of education, limited digital skills, limited access to the internet or devices, and negative perceptions of technology [7,8]. These barriers are more common among older adults and people with lower incomes. Although digital interventions show promising results in reducing stress and improving quality of life, usability and acceptance by older caregivers require user-centered design and cultural adaptation efforts [9]. In addition, recent studies have highlighted the importance of involving users and their families in the design of technological tools to increase their effectiveness and adherence [10].

In this regard, it is important to consider not only the characteristics of technological access but also the individual beliefs, attitudes, and motivations that influence a person's willingness to use these tools. Perceived usefulness and ease of use are key factors in users' acceptance of technologies. For informal caregivers, the belief that these tools can improve care is essential to encouraging their adoption. Conversely, when these tools are perceived as ineffective or as an additional burden, the likelihood of their incorporation into care practices decreases significantly [8].

Thus, it has been shown that a caregiver's well-being directly influences their openness to learning and their adoption of new technological tools. Caregivers with greater emotional and social well-being tend to participate more actively in training activities and in the use of technologies [11]. In addition, combining educational content with professional psychological support on digital platforms can enhance the positive effects of caregiving [5].

The environment also plays an important role: religious beliefs, community involvement, income level, and support networks all influence the ability to access and use technology. In contexts with limited access or greater social isolation, technology use tends to be limited, necessitating personalized support strategies [6,9].

In summary, despite the growing availability of care-oriented technologies, adoption of these tools by informal caregivers aged 60 years and older remains low, limiting their potential impact on their well-being and the quality of care they provide. This gap between technological availability and effective use makes it necessary to understand the factors that influence acceptance or rejection.

The Los Ríos region has sociodemographic and economic characteristics that create a unique context for informal care. According to the results of the 2024 Population and Housing Census, the region had a population of 398,230, with a rapid demographic transition toward an aging population: the proportion of people aged 65 or older rose from 7.1% in 1992 to 15.4% in 2024, resulting in an aging index of 89.2 older adults for every 100 children under 14, higher than the national average [12]. According to projections by the National Institute of Statistics, people aged 60 and older accounted for about one-fifth of the regional population [12]. Economically, the

region's activity is based primarily on the forestry industry, commerce, services, and tourism. The region accounts for approximately 1.3% of the national Gross Domestic Product [13]. However, it has one of the highest income poverty rates in the country (22.2%, above the national average of 17.3%), according to the 2024 CASEN Survey [14].

Furthermore, Los Ríos has been identified as one of the regions with the highest income inequality in the country, with a Gini coefficient for autonomous income of nearly 0.49 over the past decade [14]. Added to this is a high proportion of the population living in rural areas: nearly one-third (31.5%) reside in rural areas, compared with 12.7% nationwide [14]. This results in a greater geographic dispersion of caregivers and additional barriers to accessing infrastructure, connectivity, and support services. This scenario of accelerated aging, persistent inequality, and a high proportion of the population living in rural areas presents a particularly challenging context for the adoption of care technologies.

The purpose of this study is to identify the factors associated with the willingness of caregivers aged 60 and older to participate in technology-mediated health and care support activities. First, we sought to analyze differences between those who are willing to participate in technology-mediated health and care support activities and those who are not, taking into account sociodemographic variables, beliefs about technology use, and perceived barriers to access and use. Second, the study sought to identify factors associated with willingness to participate, aiming to generate evidence to guide future interventions and digital inclusion strategies targeting this population.

Materials and Methods

Design and population

A cross-sectional, descriptive, and correlational study was conducted to identify the factors associated with the willingness of informal caregivers aged 60 or older residing in the Los Ríos region of Chile to participate in technology-mediated health and care support activities. For this study, an informal caregiver was defined as a person who regularly provided care or assistance to a dependent individual without receiving compensation.

The present study involved a secondary analysis of data from a broader investigation examining the characteristics and caregiver burden of informal caregivers of dependent individuals in the Los Ríos Region. This investigation was conducted as part of the community engagement project "Conciencia Cuidados" at Universidad San Sebastián, Valdivia Campus, funded by the Regional Government of Los Ríos.

The sample consisted of 109 participants (95 women and 14 men) aged 60 years or older, selected from the original study sample through non-probabilistic convenience sampling. Recruitment was conducted through community groups, neighborhood associations, social organizations, and family health centers in the Los Ríos region. Individuals who expressed interest in participating were subsequently contacted to schedule the administration of the questionnaire in person or by telephone.

Data collection took place between April 15 and August 15, 2024. The study included individuals aged 60 or older who were residents of the Los Ríos region, provided informal care, and voluntarily agreed to participate by providing informed consent.

Data collection tool and procedure

A structured questionnaire was used that included the caregiver's sociodemographic background, characteristics related to access to and knowledge of technologies, beliefs regarding the usefulness of different technological devices for caregiving, and caregiver burden.

Operationally, the dependent variable was willingness to participate in technology-mediated health and caregiving support activities. This was assessed using an initial dichotomous (yes/no) question about willingness to participate in activities that use information and communication technologies (ICTs). Subsequently, participants who expressed willingness were asked to indicate the activities in which they would participate through the following question: "Please mark with an X the activities in which you would participate using ICTs." The response options were: caregiving training activities, a physical activity program, a group mental health program, and other. For the analysis, the dependent variable was coded as 0= unwilling and 1= willing, based on the response to the initial question.

The independent variables were grouped into three dimensions: sociodemographic characteristics, technological barriers, and attitudinal factors. These included nominal or ordinal categorical variables, as well as age, which was recorded as a quantitative variable.

Access to technology was assessed through self-report. Participants were asked whether they had access to various technological devices and resources, including mobile phones, computers, and the internet. The level of access to mobile phones and computers was assessed using a self-perceived rating scale, in which each participant classified their level of access to these devices as high, medium, or low.

Knowledge regarding cell phone use was also assessed through self-reporting, using previously established functional criteria to classify the level of technological proficiency. A high level was considered when the person reported being able to perform more complex activities, such as making video calls and making payments via the phone; a medium level, when they could use the device to search for information; and a low level, when they indicated they did not know how to use the phone or limited its use to basic functions, such as answering calls or using WhatsApp. Therefore, this variable did not correspond to an objective test of technological proficiency, but rather to a classification based on the capabilities reported by each participant.

Beliefs regarding the usefulness of care technologies were assessed by asking participants whether they believed that different devices such as a radio, computer, cell phone, and television could assist them in their caregiving tasks. Responses were recorded in three categories: "agree," "neither agree nor disagree," and "disagree."

Regarding socioeconomic variables, monthly income was defined as the total household income of the caregiver's family, expressed in Chilean pesos (CLP). The following intervals were used for descriptive analysis: ≤ $200,000; $201,000-$400,000; $401,000-$600,000; and > $600,000 Chilean pesos per month.

To assess caregiver burden, the seven-item abbreviated version of the Zarit Caregiver Burden Scale, validated in a Chilean population, was used [15]. This version shows a high correlation with the original scale (r= 0.92) and adequate internal consistency (Cronbach's α= 0.84). The total score ranges from 7 to 35 points; scores ≤16 were considered indicative of no caregiver burden, and scores ≥17 were considered indicative of severe caregiver burden.

The questionnaire was administered by three healthcare professionals who had been trained in its use to standardize how questions were asked, explain the response options, and record the information. The survey was conducted in person or by telephone, depending on each participant's availability and preference, with the same questions, response options, and classification criteria used in both formats.

Statistical analysis

The collected data were analyzed using descriptive statistics, with frequencies and percentages for categorical variables and measures of central tendency and dispersion for quantitative variables.

To address the first objective, participants were grouped into two categories: those willing to use technology and those unwilling to do so. To determine whether there were significant differences between the variables based on this classification, two types of bivariate analyses were

used: Pearson's chi-square test for categorical variables and Welch's corrected Student's t-test for quantitative variables, such as age. For the variable "cell phone access," Fisher's exact test was used instead of Pearson's chi-square test. A statistical significance level of $\alpha = 0.05$ was used.

To identify the factors associated with older caregivers' willingness to participate in technology-mediated care processes (the study's second objective), we initially estimated a standard binary logistic regression model with 14 independent variables (24 parameters after category coding), replicating the structure of the bivariate analysis described above. The full model included 101 participants, of whom 39 expressed willingness to participate. Compared with the overall sample (n= 109), eight participants were excluded due to missing data on monthly income (n= 3), knowledge of mobile phone use (n= 2), and access to a mobile phone (n= 3). The reduced model included 104 participants, with 40 events, after excluding five records with missing data on monthly income (n= 3) and knowledge of mobile phone use (n= 2).

The full standard logistic regression model exhibited complete separation in at least one category ("low" cell phone access, with zero cases willing to participate out of 20 observations), resulting in uninterpretable coefficients and standard errors (unestimable odds ratio, upper confidence interval on the order of 10^{46}) and an event-per-variable (EPV) ratio of 1.6 (39 observed events across 24 parameters), well below the conventionally recommended EPV ≥ 10 for maximum likelihood logistic regression.

Given this limitation, two complementary strategies were adopted. First, the full model was re-estimated using Firth's penalized logistic regression [16], which corrects for maximum-likelihood bias in small samples or in samples with data separation through a penalty based on Jeffreys' information. Second, since Firth's correction alone does not resolve the underlying problem of a low number of events per variable, a reduced model was constructed by collapsing variables with low-frequency categories into binary variables: educational level (elementary vs. secondary or higher education), monthly income (≤ $400,000 vs. > $400,000), knowledge of cell phone use (medium/low vs. high), internet access (no vs. yes), and beliefs about the usefulness of cell phones and computers (neutral/disagree vs. agree).

The monthly income cutoff point (> $400,000) was defined pragmatically based on the categories with the highest concentration of cases in the observed sample and does not correspond to a threshold supported by external theoretical or normative frameworks (e.g., official poverty lines); this limitation is explicitly stated and addressed in the limitations section. This reduced model, with 9 parameters and an EPV of 4.4, was also estimated using Firth regression.

Both models (full and reduced) were fitted using the logistf package in R [17] by increasing the maximum number of iterations (maxit=1000) and the maximum step size (maxstep=5) relative to the default values, as the full model did not converge with the standard parameters. Collinearity was assessed using the generalized variance inflation factor (GVIF), goodness of fit using the Hosmer-Lemeshow test, and discriminatory power using the area under the ROC curve (AUC). Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated using profile likelihood for each predictor. The reduced model is reported as the primary result because it presents a more appropriate event-to-variable ratio and better goodness of fit; the full model is reported as a sensitivity analysis.

Ethical considerations

The project received approval No. 56 from the Los Ríos Health Service Scientific Ethics Committee on March 11, 2024, an accredited body responsible for safeguarding the rights, safety, and well-being of research participants. The interviews were conducted between April 15 and August 15, 2024, by trained professionals, either in person or by telephone, depending on the participants' availability and preferences. Before each interview, the informed consent form was read aloud and explained; it was then signed by each participant in person or sent via WhatsApp for the participant to read and indicate acceptance through an online form. Furthermore, all procedures complied with ethical standards in accordance with the Declaration of Helsinki.

Results

A total of 109 caregivers aged 60 and older were surveyed to gather information on their sociodemographic characteristics, beliefs about the use of technology in caregiving, and perceived barriers to accessing such technology.

Analysis of the differences between those who expressed a willingness to participate in technology-mediated health and care support activities and those who did not

Of the total 109 older adult caregivers surveyed, 95 (87.2%) were women, and 14 (12.8%) were men. Regarding willingness to participate in technology-mediated health and care support activities, 41 participants (37.6%) indicated willingness, while 68 (62.4%) did not. To explore the differences between the two groups, three dimensions were analyzed: 1) sociodemographic characteristics of the caregiver; 2) beliefs about technological tools; and 3) barriers to access and use.

Sociodemographic characteristics of the caregiver

Statistically significant differences were observed in two variables. First, educational level showed a significant association with willingness to participate (p= 0.002), indicating that caregivers with a high school education or higher were more likely to report willingness to participate than those with only a basic education. Second, a significant difference was observed in monthly income (p= 0.036), with those willing to participate more frequently reporting household incomes above CLP 400,000 per month. The other variables did not show significant differences (Table 1).

Table 1. Sociodemographic characteristics and burden of older caregivers according to their willingness to participate in technology-mediated health and care support activities.

Variable	Willing	Unwilling	*p*-value
	n (%)		
Caregiver's age (Mean ± SD)	67.1 ± 5.6	68.6 ± 6.2	0.2
Educational level			
Higher education	8 (20)	5 (7.4)	0.002*
High school	20 (49)	18 (26)	
Elementary school	13 (32)	45 (66)	
Has children			
Yes	33 (80)	59 (87)	0.5
No	8 (20)	9 (13)	
Residence			
Urban	33 (80)	49 (72)	0.4
Rural	8 (20)	19 (28)	
Monthly income†			
> $600,000	8 (20)	7 (11)	0.036*
$401,000-600,000	21 (53)	22 (33)	
$201,000-400,000	7 (18)	27 (41)	
≤ $200,000	4 (10)	10 (15)	
Abbreviated Zarit			
Severe burden	28 (68)	53 (78)	0.3
No burden	13 (32)	15 (22)	

Pearson's chi-square test; Welch-corrected Student's t-test for quantitative variables.
†: Data on monthly household income were available for 106 participants (40 willing and 66 unwilling).
(*) indicates a statistically significant difference (p <0.05)

Table 2. Beliefs about the usefulness of technological devices for care, according to willingness to participate in technology-mediated health and care support activities.

Variable	Willing	Unwilling	*p*-value
	n (%)		
Cell phone			
Agree	37 (90)	28 (41)	
Neither agree nor disagree	1 (2.4)	20 (29)	0.001*
Disagree	3 (7.3)	20 (29)	
Television			
Agree	18 (44)	40 (59)	
Neither agree nor disagree	14 (34)	9 (13)	0.035*
Disagree	9 (22)	19 (28)	
Radio			
Agree	31 (76)	51 (75)	
Neither agree nor disagree	5 (12)	8 (12)	0.9
Disagree	5 (12)	9 (13)	
Computer			
Agree	24 (59)	11 (16)	
Neither agree nor disagree	5 (12)	15 (22)	0.001*
Disagree	12 (29)	42 (62)	

Pearson's chi-square test.
(*) indicates a statistically significant difference (p <0.05)

Beliefs about technological tools

When analyzing the intention to participate in relation to beliefs, significant differences were identified in the perception of the assistance that certain devices might have provided. Those who expressed an intention to participate tended to view cell phones (p <0.001) and computers (p <0.001) as useful tools for caregiving, compared with those who did not wish to participate. A statistically significant difference was also observed regarding the television (p= 0.035). No differences were found in the perceived helpfulness of the radio (p >0.9) (Table 2).

Access and usage barriers

The analysis revealed statistically significant differences in all variables examined. Internet access was considerably higher among those willing to participate (93% vs. 59%; p <0.001). Likewise, these caregivers reported greater access to cell phones (p <0.001, Fisher's exact test; see methodological note) and to computers (p <0.001), as well as a higher level of knowledge about cell phone use in the group that was willing to participate (41%) compared to those who were unwilling to participate (9.1%) (p <0.001) (Table 3).

None of the 20 people with limited cell phone access expressed a willingness to participate. The association between cell phone access and willingness to participate was statistically significant according to Fisher's exact test (p= 1.24×10^{-5}).

Analysis of factors associated with the willingness of caregivers aged 60 years and older to participate in technology-mediated health and care support activities

Given that the standard logistic regression model with the full set of 14 variables (24 parameters) exhibited data separation and an events-per-variable ratio of 1.6, we chose to report as the primary result a reduced model estimated using Firth's penalized logistic regression, adjusted for age, educational level (secondary/higher vs. elementary), monthly income (> $400,000 vs. ≤ $400,000), internet access, knowledge of cell phones (high vs. medium/low), favorable beliefs about the usefulness of cell phones and computers, caregiver burden, and area of residence (9 parameters, EPV= 4.4; Hosmer-Lemeshow test: χ^2= 10.82, p= 0.21, with no statistical evidence of lack of fit according to this test; AUC= 0.88).

Table 3. Access to technologies and barriers to their use based on willingness to participate in technology-mediated health and care support activities

Variable	Willing	Unwilling	*p*-value
	n (%)†		
Has Internet access			
Yes	38 (93)	40 (59)	0.001*
No	3 (7.3)	28 (41)	
Cell phone access			
High	34 (85)	31 (47)	
Medium	6 (15)	15 (23)	0.001*
Low	0 (0)	20 (30)	
Computer access			
High	14 (34)	8 (12)	
Medium	14 (34)	7 (10)	0.001*
Low	13 (32)	53 (78)	
Level of knowledge of cell phone use			
High	17 (41)	6 (9.1)	
Medium	8 (20)	11 (17)	0.001*
Low	16 (39)	49 (74)	

Pearson's chi-square test, except for the variable "cell phone access," which was analyzed using Fisher's exact test ($p= 1.24 \times 10^{-5}$).

†: The percentages were calculated based on the number of valid responses for each variable. For the variable "cell phone access," data were available for 106 participants (40 willing and 66 unwilling), with 3 missing values (1 willing and 2 unwilling). For the "level of knowledge about the phone" variable, data were available for 107 participants (41 willing and 66 unwilling), with 2 missing values, both from the unwilling group. For the "internet access" and "computer access" variables, data were available for all 109 participants.

(*) indicates a statistically significant difference (p <0.05)

In this model, two variables were statistically significantly and independently associated with the willingness to participate in technology-mediated health and care support activities: knowledge of cell phone use and a favorable belief regarding the usefulness of cell phones in care. Individuals with high knowledge of cell phone use had 3.5 times the odds of reporting willingness to participate compared with those with moderate or low knowledge (OR= 3.49; 95% CI: 1.10-12.78; p= 0.034). A favorable belief in the usefulness of cell phones in caregiving was associated with nearly eightfold higher odds of willingness to participate (OR= 7.66; 95% CI: 1.96-36.97; p= 0.003), making it the strongest association in the model. A monthly income exceeding $400,000 (OR= 1.97; 95% CI: 0.68-5.82; p= 0.21), internet access (OR= 3.04; 95% CI: 0.76-15.45; p= 0.12), educational level (OR= 1.81; 95% CI: 0.63-5.21; p= 0.27), and a favorable belief about the usefulness of computers (OR= 1.68; 95% CI: 0.55-5.06; p= 0.36) did not reach statistical significance in the adjusted model (Table 4).

As a sensitivity analysis, the full model (14 variables, 24 parameters) was also estimated using Firth regression [16]. This model showed a higher AUC (0.94) but a significant Hosmer-Lemeshow test (χ^2= 21.25; p= 0.007), indicating a lack of fit and a pattern consistent with overfitting given the low number of events per variable. In this sensitivity analysis, knowledge of cell phones remained significantly associated (moderate knowledge: OR= 0.09, 95% CI: 0.01-0.58, p= 0.010; low knowledge: OR= 0.17, 95% CI: 0.02-0.89, p= 0.036), whereas monthly income (401,000-600,000: OR= 6.80; 95% CI: 0.90-75.25; p= 0.064) and a favorable view of television (OR= 5.60; 95% CI: 1.04-59.88; p= 0.045) showed associations in a similar direction to those reported in preliminary versions of the analysis, but with a smaller magnitude and substantially wider confidence intervals than those originally estimated using standard logistic regression without correction. Given the low EPV and poor model fit, the results are presented solely for sensitivity analysis. They are not interpreted as primary findings of the study.

Table 4. Factors associated with willingness to participate in technology-mediated health and care support activities among older caregivers: Firth's reduced penalized logistic regression model

Variable	OR	95% CI	*p*-value
Level of knowledge of cell phone use (high vs. medium/low)	3.49	1.10 - 12.78	0.034*
Favorable belief about the usefulness of cell phones (yes vs. no)	7.66	1.96 - 36.97	0.003**
Monthly income (> $400,000 vs. ≤ $400,000)	1.97	0.68 - 5.82	0.213
Internet access (yes vs. no)	3.04	0.76 - 15.45	0.12
Education (secondary/higher vs. elementary)	1.81	0.63 - 5.21	0.267
Favorable belief about the usefulness of computers (yes vs. no)	1.68	0.55 - 5.06	0.358
Age	1.06	0.96 - 1.17	0.247
Severe caregiver burden (vs. no caregiver burden)	0.64	0.20 - 1.96	0.433
Rural residence (vs. urban)	0.8	0.24 - 2.59	0.707

Model estimated using Firth's penalized logistic regression. n= 104 (after excluding cases with missing data on monthly household income or knowledge of cell phone use). Events= 40; EPV= 4.4. Hosmer-Lemeshow test: χ^2= 10.82, p= 0.21. AUC= 0.88. *p <0.05; **p <0.01.

Discussion

The results of this study show that one factor associated with older caregivers' willingness to participate in technology-mediated health and care support activities is their level of knowledge of how to use a cell phone. This finding is consistent with previous studies that highlight digital literacy as a key facilitator of the adoption of health technologies among older populations [3,18].

Similarly, a positive belief regarding the usefulness of cell phones in caregiving emerged as the factor with the strongest association in the model (OR= 7.66), suggesting that the subjective perception of the usefulness of the specific device that the caregiver is already familiar with and uses daily, rather than access to technology in general, may be a key factor in the willingness to adopt new technology-mediated care modalities, such as telerehabilitation. This is consistent with the international literature, which suggests that greater perceived usefulness and greater familiarity with technology can facilitate its use [19].

These findings suggest that, in addition to access to technological devices, the skills needed to use them and perceptions of their usefulness must also be considered. Although the bivariate analysis showed significant differences in access to cell phones and computers based on willingness to participate, these variables were not included in the main multivariate model. In that model, knowledge about cell phone use and a favorable belief in the usefulness of cell phones were the factors that remained statistically significantly associated with willingness to participate.

In the adjusted model, monthly income and educational level did not reach statistical significance, unlike what was observed in the initial bivariate analysis. This discrepancy is consistent with the small number of events per variable in the original model with the full set of predictors, which generated unstable estimates (high odds ratios with extremely wide confidence intervals) for these and other variables. When the model was re-estimated using a more parsimonious structure and Firth's penalized regression, these associations weakened substantially and became non-statistically significant, suggesting that the initial estimates reflected, in part, statistical instability due to sample size rather than a robust association. This finding does not rule out the possible relevance of income and education to the willingness to participate. Still, it indicates that the evidence from this study does not support this association with the strength initially reported, and that studies with larger sample sizes are needed to clarify their role.

On the other hand, the analyses revealed that caregivers aged 60 and older who expressed a willingness to participate in technology-mediated health and care support activities tend to have greater internet access, greater familiarity with the use of technological devices, and a more positive perception of the usefulness of cell phones and computers in the context of caregiving, according to the bivariate analysis. These descriptive findings are consistent with previous research highlighting the importance of access and digital literacy in facilitating technology adoption among the older

population. However, in the adjusted multivariate model, internet access alone did not retain a statistically significant association once other variables were controlled for, suggesting that its bivariate effect may be partially explained by its correlation with technological knowledge and beliefs about utility-variables that remained significant in the adjusted model.

Although the findings of this study are consistent with international research highlighting digital literacy as a key factor in technology adoption [4,8], it is important to note that in the Latin American context, specific structural and cultural barriers persist. Previous studies show that inadequate devices and limited proficiency in their use are the main barriers preventing older adults from accessing technology-mediated health and care support services, more so than sensory or cognitive limitations. These barriers are more common among people facing economic hardship and in rural areas [20].

In addition, trust in digital services, cultural norms regarding in-person care, and the role of community networks can influence technology acceptance. These elements suggest the need for digital inclusion strategies tailored to the local sociocultural context, with an emphasis on community support and on building trust in digital health systems.

Therefore, it is necessary to investigate the specific aspects of knowledge that may influence older adults' use of healthcare technologies, such as operational knowledge of mobile devices, skills for using the information obtained, communication skills through mobile device use, and digital trust, to guide training efforts.

This underscores the need to design digital inclusion interventions-especially those aimed at older adults-that not only provide access but also strengthen practical skills for the independent use of technology, with particular attention to developing specific skills in cell phone use, given that both operational knowledge of this device and the perception of its usefulness were the factors most strongly associated with willingness to participate in this study.

Limitations

Among the main limitations of this study is that the sampling design was non-probabilistic and based on convenience sampling, which limits the generalizability of the results to the entire population of older caregivers. Additionally, because recruitment was conducted through social organizations, neighborhood associations, and community health centers, the sample may overrepresent individuals with greater social participation and community connectedness compared with more isolated older caregivers, potentially inflating the magnitude of the observed associations between connectedness-related variables and willingness to participate in technology-mediated activities. Nevertheless, this limitation does not invalidate the exploratory value of the study: in an area with limited prior evidence in the region and within the Latin American context, identifying which factors are associated with willingness to participate in technology-mediated activities, even in a sample with this selection bias, provides concrete hypotheses and priority variables for future probabilistic studies.

Regarding the instrument used, although the questionnaire was structured and partially validated in previous studies, it relies on self-reporting, which may introduce biases related to social desirability or item interpretation, especially among older adults. This self-report bias is, however, a common and expected limitation in studies of perceptions and attitudes toward technology, and it does not diminish the value of identifying associations consistent with the international literature on digital literacy. Finally, the sample size (n= 109, 41 events) limited the ability to reliably estimate a multivariate model with many predictors, leading to the use of a reduced model and Firth's penalized regression. However, while these strategies mitigate the problem, they do not eliminate it, and the findings of this study should be considered preliminary evidence requiring confirmation in larger samples.

Furthermore, the cross-sectional design of the study prevents us from establishing the temporal sequence of the observed associations and determining causal relationships between the analyzed factors and the willingness to participate in technology-mediated health and care support activities. Additionally, excluding participants with missing data for variables included in the multivariate model may have introduced bias, especially if the missing data were related to participant characteristics or willingness to participate. Nor can the presence of residual confounding due to unmeasured or insufficiently controlled factors be ruled out. Finally, analytical decisions regarding the selection and recoding of variables, including the monthly income cutoff (> $400,000 vs. ≤ $400,000), may have influenced the estimates and the interpretation of the associations. These considerations underscore the need to interpret the results with caution and to confirm them through studies with larger samples and predefined analytical decisions.

Despite these limitations, the results provide relevant information for developing strategies for digital inclusion and territorial well-being in the Los Ríos region. We suggest moving forward with digital literacy programs tailored to the needs of older caregivers, with an emphasis on developing operational skills and confidence in using cell phones in particular, while integrating intersectoral actions across health, education, and social services. These initiatives could align with the public policies on active aging and digital health promoted by the Ministry of Health and the National Service for Older Adults, helping to reduce digital divides and encourage the active participation of older caregivers in health and caregiving support activities.

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