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Article

Intervention Through IoT Technology and Home Support in Older Adults from Rural Areas

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Abstract

Background: Spain has an increasingly aging population in rural areas. These individuals often face the burden of illness and the limitations it causes in solitude, leading to greater impacts on their health and quality of life. Therefore, the aim of this study is to preserve the capacities of older adults living in rural settings through care and digitalization with IoT Technology, in order to ensure safety and autonomy in their homes and to provide vital emotional support in the final stage of their lives. **Material and methods:** A longitudinal study was conducted with a sample of 144 older adults from rural areas who received home support through a Silver caregiver and IoT Technology. **Results:** Statistically significant differences were observed in cognitive status, anxiety, depression, family functionality, social support, life satisfaction, and quality of life. **Conclusions:** The results of this study support the effectiveness of combining traditional caregiving with IoT Technology to improve health-related quality of life and well-being in older adults living in rural areas. This combination offers a comprehensive approach that addresses both the physical and emotional needs of this population group.

Keywords: IoT technology; Silver caregiver; rural areas; older adults; autonomy; quality of life; health status; safety

1. Introduction

In recent decades, life expectancy has experienced remarkable growth. This achievement, although positive, brings with it a new challenge for societies: population aging. As noted in [1], this phenomenon generates a series of challenges that we must face. Aging can be defined as “a dynamic, gradual, natural, and inevitable process that develops in the biological, psychological, and social aspects of individuals and is structured around time” [2,3]. Likewise, when discussing the phenomenon of population aging, the importance of addressing this issue in the field of health is highlighted, since it is our responsibility to meet the new needs generated by demographic dynamics and the increase in demand for health services from the elderly population [4–6]. According to the World Health Organization (WHO) bulletin on aging, by the year 2050 there will be more people over 65 years of age than children under 14 years of age [7].

From a biological perspective, aging occurs as a result of the progressive accumulation of various types of molecular and cellular damage over time. This leads to a gradual decline in physical and mental capacities, an increased risk of disease, and ultimately, death [8,9]. Moreover, in the context of Spain, the rural environment covers 90% of the territory and is home to approximately 20% of the older population [10]. In 2019, Castilla y León was the second autonomous community to record the highest percentage of people over 65 years of age, with 25.3% [11]. Thus, it is expected that rural areas will be predominantly populated by older people. Therefore, the autonomous communities of Spain with a more aged population also tend to be the most rural, as in the case of Castilla y León, characterized by smaller population centers [12], a phenomenon known as the “empty Spain” [13].

Current transformations are resulting in many older people becoming disconnected from certain services. Several studies have highlighted specific characteristics of elder care in rural settings, such as difficulties in accessing hospital systems, social centers, or day centers. This is due to the fact that the network of social and health services and public support is less robust in rural areas compared to urban ones [14]. Therefore, one of the main objectives of public health today is to promote and maintain the health and well-being of an increasingly diverse aging population. In formulating a public health response to aging, the WHO [15] points out that it is important to consider not only the factors that mitigate losses associated with old age, but also those that can strengthen recovery, adaptation, and psychosocial growth. In other words, the aim is to maintain, strengthen, and/or compensate for the losses of independence in life.

It is important to note that the burden of disease among the older adult population is significant due to the presence of chronic non-communicable diseases, with a marked increase observed in the burden of mental illnesses as a result of the various changes and adaptations older adults must face at this stage of life. Among the recognized changes in older people is the feeling of loneliness, which is considered a predictor of anxiety and depression, as well as the development of other health conditions [16–19].

The consequences of loneliness, or the fact that these older adults live alone, can be broken down into physical, psychological, and social dimensions. In the physical dimension, alterations may arise in their functional and nutritional status, limitations in carrying out Activities of Daily Living (ADLs) or Instrumental Activities of Daily Living (IADLs), balance and gait problems that lead to falls, or difficulties regarding their autonomy and independence, which may translate into a risk of disability and frailty in older people. In the psychological dimension, anxiety or depression, among others, may be experienced. Meanwhile, in the social dimension, social prejudice, feelings of isolation related to a lack of family or social support may emerge [20,21]. All of this directly impacts the Quality of Life (QoL) of these individuals and their life satisfaction. Loneliness tends to increase among older adults who are not institutionalized as they advance in age [22]. In this context, it becomes crucial to develop monitoring programs and interventions for the prevention of loneliness and the maintenance of health in this population group [23].

The existence of Information and Communication Technologies (ICTs) offers older adults the opportunity to enhance and improve their development both individually and socially, serving as support to promote their autonomy and focusing on prevention and care; thus contributing to improving their QoL in technical, economic, political, and cultural aspects [24,25]. As evidenced by other previous research [26,27], assistive technologies and new technologies play a significant role in this regard. However, due to the constant change, creation, and updating of technology, there arises the need to carry out this study using Internet of Things (IoT) technology [28,29].

IoT technology refers to the grouping and interconnection of various devices and objects through an internet network, where they can connect, interact, and exchange data. These objects may range from sensors to mechanical devices embedded in completely everyday items such as a door, a refrigerator, footwear, or a bed. This enables seamless communication between people with minimal human intervention, with technology itself responsible for collecting data, recording, monitoring, or adjusting each interaction among connected things, directly linking the physical and digital worlds and cooperating with one another [30–32]. De esta forma, el objetivo de este estudio es, por tanto, conseguir el mantenimiento de las capacidades en las personas mayores que viven solas en un medio rural, a través de cuidados y digitalización con Tecnología IoT para garantizar seguridad y autonomía en sus domicilios y proporcionar un soporte emocional vital en la última etapa de su vida.

2. Materials and Methods

2.1. Study Design and Participants

This longitudinal study was carried out by the University of Burgos (HUBU) in collaboration with the Provincial Council of Zamora, the Regional Government of Castilla y León, and Zamora Silver Economy Territory. The sample included 144 older adults living in rural areas.

The inclusion criteria were: (1) dependent users from the Tierra de Campos-Pan-Lampreana area, (2) signing of informed consent, (3) absence of cognitive impairment, (4) autonomy to carry out ADLs, and (5) living alone with/without family support. As exclusion criteria, all participants who did not sign the informed consent and those with total or severe dependence, measured using the Barthel Index, were excluded.

2.2. Procedure

For the collection of the sample in this study, the Regional Government of Castilla y León first selected, during 2022, the unique project entitled “Silver Caregivers and Rural Innovation in Elderly Care Contexts”, developed by the Provincial Council of Zamora. This project was communicated to the Ministry for the Ecological Transition and the Demographic Challenge, as stated in the certificate issued by the General Secretariat for the Demographic Challenge of said Ministry. The purpose of this project was to contribute to the sustainable development of the Tierra de Campos-Pan-Lampreana area (Zamora) through the implementation of a productive and innovative ecosystem based on the care economy and digitalization, consolidating the objectives of the Silver Economy strategy in each of the municipalities within the region.

Likewise, an innovative plan was launched to promote and strengthen the role of the “Silver Caregiver,” a professional who fosters autonomy and supports the permanence of older adults in their homes through a process of preventive accompaniment and monitoring of their routines in their everyday environment, in coordination with other agents involved in care and attention.

The aim, therefore, was to stimulate specialized and high-quality care for elderly and dependent residents, respond to cases of isolation and loneliness, foster autonomy at advanced ages, support a longer stay in their homes, and safeguard their organic, functional, cognitive, emotional, and material well-being, while promoting social inclusion, self-determination, respect for their rights, and personal development. This project encompasses all these factors, digitalizing the care and attention provided to older adults through ICT solutions (such as remote care based on IoT technology, intelligent systems for monitoring home routines), with special emphasis on the “Silver Caregivers” as the main actors in the implementation of these new techniques.

The municipalities involved were: Almaraz de Duero, Belver de los Montes, Benegiles, Cañizo, Castronuevo, Coreses, Manganeses de la Lampreana, Molacillos, Monfarracinos, Roales, San Cebrián de Castro, Valcabado, Villafáfila, Villanueva del Campo, Villarín de Campos, and Villaseco del Pan (Zamora, Spain).

Data collection was carried out by designated personnel, and the data were anonymized before being shared with the research team, remaining anonymous and aggregated from that moment onward. Informed consent was obtained from the study participants, ensuring voluntariness and anonymity. Data processing was carried out in compliance with the European Data Protection Regulation and Organic Law 3/2018 on the Protection of Personal Data and the Guarantee of Digital Rights.

2.3. Intervention

To carry this out, the new profile of “Silver Caregiver” was implemented, with one Silver Caregiver assigned per municipality. These caregivers were trained to promote autonomy, support users in their homes, and assist in monitoring their routines. Each caregiver was assigned specific tasks, which they reported to their supervisors within the established deadlines. Their responsibilities included remote monitoring of daily tasks; establishment of routines; management of resources and

incidents; functional, cognitive, social, and emotional assessment of users; intervention through accompaniment to healthcare centers; occasional support with household tasks; assistance with personal care; support in administrative procedures; provision of companionship and recreational activities; preparation of reports; creation of individual records with routines and schedules; and creation of incident reports, among others.

Each municipality was also provided with resource-monitoring equipment to oversee users' routines. The technology applied in the project was IoT technology. This technology makes it possible to create an environment that monitors people's activities, recording, storing, processing, and analyzing information to identify activity patterns. Its main objectives include, among others: generating new services and professionals dedicated to the care of older adults living in rural settings by implementing service models based on the use of new technologies to address isolation and loneliness; focusing on prevention and care for older adults living alone; and facilitating the provision of information to family members, guardians, or professionals responsible for the users' condition and progress.

The technological kit included vibration, motion, and door sensors that were installed in users' homes in locations and objects such as the refrigerator, bathroom, hallways, living room, kitchen, bedroom, doors, medication pillbox, walking aid, main entrance, and bed.

2.4. Instruments

Sociodemographic information was collected, along with the main pathology and a functional assessment. The level of autonomy of the users in performing ADLs and IADLs was measured, as well as their cognitive level, anxiety, depression, family functionality, perceived social support, nutritional status, life satisfaction, and quality of life (QoL), through a battery of evaluation tools. The instruments used for assessment were as follows:

Barthel Index. This scale evaluates functional status and the level of independence in patient self-care. It is applied through direct observation and assesses 10 ADLs with a score ranging from 0 to 100 points. It shows good reproducibility, with weighted kappa correlation coefficients of 0.98 intra-observer and above 0.88 inter-observer. It also has excellent internal consistency, demonstrated by a Cronbach's alpha of 0.90 to 0.92. The established cut-off points include independence (100), slight dependence (91–99), moderate dependence (61–90), severe dependence (21–60), and total dependence (<21) [33,34].

Short Physical Performance Battery (SPPB). A simple geriatric performance test. It is a valuable tool for assessing mobility limitations. It has three sections: balance, gait, and the ability to stand up and sit down. Scores range from 0 to 12, with higher scores indicating better functional status. It has a Cronbach's alpha of 0.86, showing good internal consistency, reliability, and validity [35].

Lawton and Brody Scale. Evaluates physical autonomy in performing IADLs. It examines 8 IADLs using a questionnaire administered either directly to the person or their caregiver. The application time is approximately 5 minutes and it is useful for evaluating the functional capacity of any individual. Each item scores between 0 and 1, with a total score from 0 to 8 points, where a lower score indicates greater dependence. This questionnaire has been translated, adapted, and validated in Spanish. It demonstrates high intra- and inter-observer reproducibility (0.94) and good reliability [36–38].

Mini-Mental State Examination (MMSE). A widely used tool to assess cognitive impairment in older adults. It evaluates several cognitive areas with a score ranging from 0 to 35, with higher scores indicating better cognitive status. It has good internal consistency (Cronbach's alpha = 0.88) and good test-retest reliability [39,40].

Yesavage Geriatric Depression Scale. Assesses depressive symptoms in individuals over 65 years of age. Scores are interpreted as follows: 0–5 normal, 6–9 mild depression, and >10 established depression. It demonstrates good reliability and validity [41].

Goldberg Anxiety and Depression Scale. A tool for evaluating depressive and anxiety symptoms in clinical populations. It consists of 18 items, with subscale scores ranging from 0 to 9, where higher

scores reflect worse anxious or depressive status. Overall internal consistency is satisfactory ($\alpha = 0.80$) [42].

APGAR Family Functionality Questionnaire. Assesses family functionality in older adults. It consists of 5 items scored from 0 to 3, with lower scores indicating severe dysfunction. It is a reliable and appropriate instrument ($\alpha = 0.71\text{--}0.83$) [43,44].

Duke-UNC Functional Social Support Questionnaire. Evaluates perceived social support and has been validated in the Spanish population. It contains 11 items, with higher scores reflecting greater perceived support. Scores <32 indicate low perceived social support. It shows adequate internal consistency and construct validity [45].

Satisfaction With Life Scale (SWLS). Measures individuals’ overall judgments of satisfaction with life. It consists of 5 items rated on a 7-point Likert scale, where higher scores represent greater satisfaction. Interpretation of scores is as follows: 5–9 extremely dissatisfied, 10–14 dissatisfied, 15–19 slightly dissatisfied, 20–24 slightly satisfied, 25–29 satisfied, and 30–35 extremely satisfied. It has demonstrated high reliability and validity [46].

EuroQol-5D. Measures Health-Related Quality of Life (HRQoL) in the general population and in patients with different pathologies. It includes five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Lower scores indicate better perceived HRQoL in each dimension. Additionally, it includes a visual analog scale (VAS) from 0 to 100, with higher scores indicating the best imaginable health. It is quick to administer and provides valid and reliable results in the Spanish population [47].

Finally, difficulty climbing stairs was also measured using a quantitative scale from 0 to 10, where 0 represented no difficulty and 10 represented maximum difficulty.

A summary of the variables analyzed and the respective measurement instruments is presented in Table 1.

Table 1. Variables and instruments.

Instrument	Variable
Barthel	Functional status, level of independence for ADLs
SPPB	Mobility limitations
Lawton y Brody	Autonomy for IADLs
MMSE	Cognitive status
Yesavage	Depressive symptoms
Goldberg	Anxiety and depressive symptoms
Apgar	Family functionality
Duke Unc	Social support
SWLS	Life satisfaction
EuroQol-5D	HRQoL

ADLs: Activities of Daily Living; SPPB: Short Physical Performance Battery; IADLs: Instrumental Activities of Daily Living; MMSE: Minimental State Examination; SWLS: Satisfaction With Life Scale; HRQoL: Health-Related Quality of Life (HRQoL).

2.5. Statistical Analysis

Descriptive analyses of the sample characteristics were performed, expressing categorical variables as absolute frequencies and percentages, and continuous variables as means and standard deviations (SD). The normality of the dataset was tested using the Kolmogorov-Smirnov test.

To evaluate differences between the assessments conducted before and after the intervention, a paired-samples Student’s t-test was applied. In addition, an ANCOVA analysis was performed, with sex and the main pathologies of the sample included as covariates. Statistical analyses were carried out using SPSS software, version 28 (IBM Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

3. Results

The sample consisted of 144 older adults living in rural areas. A higher percentage of women were found in this setting, as well as a greater proportion living alone. All participants presented with some type of pathology, and their mean age was high. Table 2 below presents the sociodemographic and clinical data collected from the sample.

Table 2. Sociodemographic and Clinical Data.

Variables		N (144)	%
Sex	Male	52	36.1
	Female	92	63.9
Age	81.10 ± 7.712 (44-94)		
Principal pathology	Cardiovascular-stroke	38	26.4
	Dementia–Parkinson’s disease	13	9.0
	Pulmonary	4	2.8
	Endocrine–Metabolic	84	58.3
	Cancer	5	3.5
Civil status	Married	31	21.5
	Single	28	19.4
	Widowed	85	59
Currently lives	Living alone	96	66.7
	Living with a family member or caregiver	48	33.4
Home has stairs	Yes	88	61.1
	No	56	38.9

After the intervention implemented with the participants, statistically significant differences were observed between the results of the first and second evaluations (Table 3) in the variables cognitive status ($p < 0.001$), depressive symptoms ($p < 0.001$), anxiety and depressive symptoms ($p = 0.022$), family functionality ($p = 0.004$), and life satisfaction ($p < 0.001$). Additionally, within HRQoL as measured by the EuroQol-5D, significant differences were found in the VAS scale ($p < 0.001$), pain dimension ($p = 0.015$), and anxiety dimension ($p = 0.008$). Furthermore, a significant improvement was observed in difficulty climbing stairs ($p = 0.008$). Overall, significant improvements were identified in the scores of these variables.

Table 3. Paired-samples Student’s t-test between pre- and post-intervention scores.

Variables (Instruments)	Mean First Evaluation (SD)	Mean Second Evaluation (SD)	Mean difference (SD)	CI 95%		p
				LI	LS	
Functional status, level of independence for ADLs (Barthel)	91.44 (17.177)	90.85 (21.049)	0.590 (11.023)	-1.225	2.406	0.522
Mobility limitations (SPPB)	5.97 (3.534)	5.99 (3.837)	-0.021 (2.787)	-0.480	0.438	0.929
Autonomy for IADLs (Lawton & Brody)	6.13 (1.997)	6.58 (2.749)	-0.451 (2.781)	-0.909	0.007	0.721
Cognitive status (MMSE)	28.35 (6.684)	30.63 (6.058)	-2.278 (5.189)	-0.345	0.498	<0.001**
Depressive symptoms (Yesavage)	4.03 (3.319)	2.91 (1.138)	1.125 (2.838)	-3.133	-1.423	<0.001**
Anxiety and depressive symptoms (Goldberg)	5.20 (4.598)	4.22 (5.289)	0.979 (5.063)	0.145	1.813	0.022*
Family functionality (APGAR)	8.63 (3.553)	9.31 (1.756)	-0.681 (2.825)	-1.146	-0.215	0.004**
Social support (Duke-UNC)	43.72 (9.946)	46.55 (8.973)	-2.823 (9.198)	-1.053	-5.272	<0.001**
Life satisfaction (SWLS)	18.23 (4.424)	19.92 (4.694)	-1.684 (3.833)	-2.314	-1.053	<0.001**
HRQoL, VAS scale (EuroQol-5D)	59.65 (20.532)	71.18 (21.629)	-11.528 (22.789)	-15.282	-7.774	<0.001**
Mobility dimension (EuroQol-5D)	1.47 (0.528)	1.47 (0.541)	0.000 (0.515)	-0.085	0.85	1.000

Self-care dimension (EuroQol-5D)	1.27 (0.505)	1.22 (0.465)	0.049 (0.448)	-0.025	0.122	0.195
Usual activities dimension (EuroQol-5D)	1.39 (0.543)	1.38 (0.613)	0.014 (0.567)	-0.080	0.107	0.769
Pain dimension (EuroQol-5D)	1.73 (0.594)	1.61 (0.593)	0.118 (0.573)	0.024	0.212	0.015*
Anxiety dimension (EuroQol-5D)	1.24 (0.446)	1.15 (0.392)	0.097 (0.432)	0.026	0.168	0.008**
Difficulty climbing stairs	5.22 (3.424)	4.51 (3.530)	0.708 (3.150)	0.189	1.227	0.008**

SD: Standard Deviation; CI: Confiance Interval; ADLs: Activities of Daily Living; SPPB: Short Physical Performance Battery; IADLs: Instrumental Activities of Daily Living; MMSE: Minimental State Examination; SWLS: Satisfaction With Life Scale; Health-Related Quality of Life (HRQoL); VAS: Visual Analogue Scale. *p<0.005; **p<0.01.

An ANCOVA analysis was performed with the significant variables from the previous analysis. Taking participants’ sex as a covariate, statistically significant differences were observed between pre- and post-intervention only in the pain dimension (p = 0.020) of the EuroQol-5D instrument. Men showed a better perception of their HRQoL in the pain dimension (Table 4).

Table 4. ANCOVA Analysis between Sex and Cognitive Status.

Variables	Group	First evaluation	Second evaluation	Mean difference	p	95% CI		Observed power
		Mean (SD)	Mean (SD)	(SD)		LI	LS	
Cognitive status (MMSE)	Female	1.79 (0.584)	1.72 (0.599)	0.204 (0.087)	0.020*	0.032	0.376	0.645
	Male	1.62 (0.599)	1.42 (0.537)	-0.204 (0.087)		-0.376	-0.032	

MMSE: Minimental State Examination . *p<0.005; **p<0.01.

An ANCOVA analysis was conducted with the significant variables from Table 3. Taking the participants’ main pathology as a covariate, statistically significant differences were observed between the pre- and post-intervention assessments in social support (p=0.040), life satisfaction (p=0.012), and HRQoL measured with the VAS scale (p=0.010) (Table 5).

Table 5. ANCOVA Analysis of Significant Variables According to Main Pathology.

Variable s	Principal pathology	First evaluation	Second evaluation	Principal pathology	First evaluation	Second evaluation	Mean difference (SD)	p	95% CI		Observed power
		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)			LI	LS	
Social Support (Duke Unc)	Cardiovascular/Stroke	41.39 (9.351)	42.95 (9.992)	Dementia–Parkinson’s disease	42.46 (12.292)	49.31 (6.750)	-5.85 (2.399)	0.016*	-10.60	-1.11	0.715
				Pulmonary	40.00 (14.765)	51.00 (4.899)	-8.71 (3.925)	0.028*	-16.47	-0.95	
				Endocrine–Metabolic	44.98 (9.555)	47.58 (8.511)	-2.93 (1.477)	0.049*	-5.85	-0.01	
Life Satisfact ion (SWLS)	Cardiovascular/Stroke	16.55 (4.144)	17.68 (4.497)	Dementia–Parkinson’s disease	15.15 (3.760)	19.69 (5.498)	-2.96 (1.121)	0.009**	-5.17	-0.74	0.837
				Pulmonary	19.74 (4.193)	25.00 (0.000)	-5.13 (1.8409)	0.006**	-8.77	-1.50	
				Endocrine–Metabolic	19.36 (4.298)	20.63 (4.401)	4.10 (1.778)	0.022*	0.59	7.62	
HRQoL, VAS Scale	Cardiovascular/Stroke	52.89 (17.228)	65.00 (18.995)	Dementia–Parkinson’s disease	59.23 (23.260)	55.38 (30.988)	12.20 (6.152)	0.049*	0.04	24.36	0.848

(EuroQol-5D)	Demencia/Parkinson	59.23	55.38	Pulmonary	62.50	80.00	-23.28	0035*	-44.86	-1.70
		(23.260)	(30.988)	Endocrine–Metabolic	(5.000)	(14.142)	(10.914)			
					62.38	76.07	-19.40	<0.001**	-30.66	-8.14
					(21.432)	(20.061)	(5.693)			

SWLS: Satisfaction With Life Scale; Health-Related Quality of Life (HRQoL); VAS: Visual Analogue Scale. *p<0.005; **p<0.01.

4. Discussion

The aim of this study was to maintain the capacities of older adults living in rural areas through care and digitalization with IoT Technology, in order to ensure safety and autonomy in their homes and to provide vital emotional support in the final stage of life.

The use of new technologies, such as IoT Technology, enables older adults to enhance and enrich their individual and social development, while at the same time optimizing their quality of life from technical, economic, political, and cultural perspectives [52]. Previous research has shown that assistive tools and new technologies can play a crucial role in this area. However, their specificity is limited due to the constant change, development, and updating of technology [53,54].

Our results show that more than half of the rural population is composed of women, with an average age above 80 years, most of whom live alone. Cardiovascular and metabolic/endocrine conditions were the predominant pathologies. Statistically significant differences were also observed after the intervention involving care and the application of IoT Technology, particularly in cognitive status, depressive symptoms, anxiety symptoms, family functionality, life satisfaction, HRQoL (specifically in the pain dimension, anxiety dimension, and VAS scale), and difficulty climbing stairs. All variables improved, thus achieving positive outcomes across all measures.

The assessment of HRQoL provides a comprehensive view of the diverse aspects that influence well-being during aging. In this context, HRQoL is understood as a multifaceted process that encompasses health status, mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. However, older adults often prioritize maintaining functional capacity and avoiding disabling diseases in order to experience healthy aging and a good quality of life. HRQoL has become one of the most important indicators in social and health interventions, particularly in the field of primary health care [55,56].

The results show statistically significant differences between the pre- and post-test in HRQoL, specifically in the Pain Dimension, when sex was considered as a covariate. In this case, men reported a better perception of their HRQoL in the Pain Dimension. Particularly relevant is the observation that gender differences influence the perception of HRQoL regarding pain. This highlights the need to consider gender differences when designing health interventions for older adults. In general terms, findings from several studies confirm that women experience aging with a lower HRQoL. Women have undergone a more complex life course, both physiologically [57] and socially, due to the repercussions associated with multiple caregiving responsibilities [58]. Nonetheless, another study also indicates that mental health problems are more common among older women, as evidenced by both national [59] and international research [60]. In terms of objective health, a higher prevalence of health problems has been observed among women [55].

Statistically significant differences were also found between pre-test and post-test scores when considering participants’ main pathology. Specifically, significant differences were observed in social support between those with cardiovascular/stroke conditions and those with dementia/Parkinson’s disease, pulmonary disease, or metabolic/endocrine conditions. All of these groups showed greater social support compared to participants with cardiovascular/stroke conditions. Regarding life satisfaction, participants with cardiovascular/stroke conditions reported being slightly dissatisfied after the program, while those with dementia/Parkinson’s and metabolic/endocrine conditions reported being slightly satisfied, and those with pulmonary disease reported being satisfied. Nevertheless, all groups improved their life satisfaction scores after the intervention. Finally, statistically significant differences were obtained after the intervention in HRQoL, as measured by

the VAS scale. Participants with pulmonary disease showed the highest HRQoL scores, followed by those with metabolic/endocrine, cardiovascular/stroke, and lastly dementia/Parkinson's conditions. All groups improved their HRQoL scores after the intervention. These findings underscore the importance of tailoring interventions to the specific needs of each patient group.

So far, no studies have reported an intervention similar to the one presented here. However, it has been shown that individuals with various pathologies often experience a decline in HRQoL due to physical or cognitive limitations, anxiety, emotional challenges, or uncertainty. Social support can help mitigate these negative effects and is essential in the process [61–63]. Life satisfaction often improves when patients feel accompanied and understood by both their loved ones and healthcare professionals [64–67]. In this sense, IoT technology and home care can help monitor patient safety at home, facilitate communication and symptom follow-up, provide continuous monitoring and alerts, track health data, and/or deliver personalized self-care reminders, thereby offering greater reassurance and improving some of these aspects [68,69].

One of the key contributions of this study is the demonstration of significant improvements in various measures of well-being and mental and physical health after implementing the intervention, which combines traditional care with IoT technology. These improvements were observed in variables such as cognitive status, depressive and anxiety symptoms, family functioning, life satisfaction, and HRQoL.

As study limitations, it should be noted that the sample size may be limited, which could affect the ability to generalize the results to a broader population of older adults living in rural settings. The follow-up period may also be relatively short compared to the chronic and progressive nature of many diseases in older adults. Furthermore, the study design may present inherent limitations, such as the absence of a randomized control group or the presence of selection or information biases, which may affect internal validity and the interpretation of results. Additionally, the use of some subjective measures could introduce biases in the interpretation of the findings.

5. Conclusions

In conclusion, the results of this study support the effectiveness of combining traditional care with IoT technology to improve HRQoL and well-being among older adults in rural settings. This combination provides a comprehensive approach that addresses both the physical and emotional needs of this population group. Furthermore, significant differences were observed in the perception of well-being according to participants' gender and main pathology.

It is crucial to take these differences into account when designing health and care interventions tailored to each group, in order to maximize their effectiveness and appropriateness to individual needs. In addition, the use of IoT technology in the care of older adults in rural areas emerges as a promising tool to enhance safety, autonomy, and HRQoL in this population. Its integration into care interventions can offer innovative and effective solutions to address the specific challenges faced by older adults in rural environments.

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