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Navigating Through Innovation in Elderly's Health: A Scoping Review of Digital Health Interventions

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Objectives: Comprehensively map and summarize digital health initiatives for the elderly and caregivers.

Methods: Scoping review between April and May 2022 based on Joanna Briggs methodology. Databases used included PubMed, Cochrane Library, CINAHL Plus, and Web of Science, along with grey literature and hand searches. Two reviewers independently conducted screening and eligibility phases, with a third resolving disagreements. Data were thematically analyzed.

Results: The review included 421 documents. Most documents were published between 2013 and 2022, with a recent increase. Most studies, originating from high-income countries, focused on home applications and were mainly in the testing and validation stages. Telephones and computers were the predominant devices. Health objectives included monitoring, prevention, and treatment, with interventions utilizing directed communication and personal health monitoring for individuals, and telemedicine and decision support for healthcare providers.

Conclusion: Increasing integration of technology in older adults' lives, along with their increasing proficiency, is driving a significant rise in digital health interventions. Despite this growth, further research in middle- and low-income countries, for caregivers and evaluating effectiveness and feasibility of these technological interventions is needed.

Keywords: digital health, elderly, caregiver, reviews, telemedicine

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INTRODUCTION

Population aging is a worldwide phenomenon, and it is estimated that by 2050, two billion people will be 60 years of age and older (22% of the population). Eighty percent of them will be living in low- and middle-income countries [1].

Population aging signifies improved living conditions and health status in countries; however, it also presents a series of health and social challenges that need to be addressed. Moreover, due to physical and functional limitations, some elderly individuals require a caregiver, a key figure who provides care, makes decisions, and connects them with the healthcare system [2–4].

When examining equity in healthcare access, disparities become evident as certain populations encounter unmet health needs due to factors such as limited-service availability, administrative and cultural barriers, substandard service quality, high costs, and extended waiting times. The implementation of digital health technologies can partially alleviate these disparities by enhancing the interaction between healthcare providers and the population [5].

Digital health is defined as "the use of information and communication technology (ICT) in support of health and related areas" [5]. Technologies provide concrete opportunities to address health system challenges and offer possibilities to improve access, coverage and quality of services [6]. Their use, especially in low-resource settings, could enable progress toward universal health coverage (UHC), with a more equitable and resource-efficient model of care [7].

Digital health technologies have emerged as a significant area of development and research aimed at addressing various health needs [5]. In 2018, the World Health Assembly formally recognized their potential in advancing towards Universal Health Coverage (UHC). In its resolution [8], the Assembly called upon health ministries to evaluate the use of digital health technologies and prioritize their development, assessment, implementation, scaling up, and increased use. Furthermore, the resolution tasked the World Health Organization (WHO) with providing policy guidance in this field [5].

The utilization of digital health technologies has been extensively acknowledged for its applicability across various target groups, including patients, healthcare professionals, and decision-makers. This technology encompasses a broad range of functionalities such as electronic health records, emergency alert systems, fall detection sensors, and remote patient monitoring, all of which are continually advancing due to the dynamic nature of the field [5].

The SARS-CoV-2 pandemic has notably accelerated the adoption and development of health technologies. However, there is a pressing need for systematic evidence, particularly regarding vulnerable populations like the elderly, to inform effective development and implementation strategies. Seniors possess diverse healthcare needs but frequently encounter difficulties in utilizing these technologies. Therefore, it is crucial to design digital health solutions that are user-friendly and tailored to their specific needs and preferences, ensuring that healthcare services remain accessible, efficient, and effective. Digital health innovations can enhance care quality for seniors by improving service delivery, optimizing data management, and facilitating better communication between patients and healthcare providers [5, 9].

The aim of this scoping review is to comprehensively map and summarize digital health initiatives, strategies, programs, innovations or policies for the elderly or their caregivers.

METHODS

The scoping review was conducted following the Joanna Briggs Institute (JBI) Guidance for conducting systematic scoping reviews [10] and the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [11].

Review Question

What initiatives, strategies, programs, innovations, or digital health policies are aimed at older adults or their caregivers?

Inclusion Criteria

The inclusion criteria were formulated based on the components of the Population, Concept, and Context (PCC) framework as outlined by the JBI [10]:

- Population: elderly or their caregivers (formal and informal). Elderly is defined as individuals at a stage of life characterized by biological, psychological, and social changes associated with aging. For this study, the population aged 60 years and older was considered, in accordance with the definition established by the World Health Organization [12].
- Concept: the core topic or phenomenon of interest are digital health initiatives, strategies, programs, innovations, policies, oriented to older people or their caregivers. Digital health is understood as "the use of information and communication technology in support of health and related areas." They are considered those with which the elderly person or caregiver interacts, or that fulfill the function of being a facilitator in their daily life related to some area of health.
- Context: regarding geographic location and specific settings, the scoping considers initiatives implemented in any country or setting, including hospitals, primary care facilities, community health services, elder care centers and residences, other healthcare services, private homes, and both rural and urban settings.

Exclusion Criteria

Documents were excluded if they were interviews, opinion letters, or other types that did not contain their own methods and results; related exclusively at other age groups, surgical practices or pathology diagnosis; inquired exclusively into aspects of acceptability (i.e., the degree to which population or specific social groups accept the technology and the factors that increase or decrease the likelihood of their use); contained

terms as ICT (which is not the subject of this review: intensive chemotherapy, intracranial tumors, Islamabad Capital Territory, among others); were clinical trial protocols, or only described the technology (or its development) without having been tested or used by elderly or caregivers.

Included terms like ICT (that, in our context, means Information and Communication Technology) with meanings unrelated to this review, such as "intensive chemotherapy," "intracranial tumors," or "Islamabad Capital Territory," were excluded. This approach allowed to comprehensively capture studies aligned with our focus while filtering out unrelated documents using the same acronym.

Databases and Search Strategy

The following biomedical data sources were consulted: PubMed (NCBI), CINAHL Plus with Full Text (EBSCO), Academic Search Ultimate (EBSCO), Cochrane Library (free access by Ministry of Health, Chile), Rehabilitation and Sports Medicine (EBSCO), Web of Science (Clarivate), Scielo.org and Emerald.

Also, grey literature (manuals, technical documents, scientific conference reports and conference presentations) was reviewed in World Health Organization and Pan American Health Organization.

Finally, a hand search was performed in OpenAire/Explore, Working with Older People, Smart Homecare Technology and TeleHealth, Journal of Assistive Technologies and Quality in Ageing and Older Adults and Google Scholar.

To identify relevant studies, a seasoned biomedical librarian (AJ) and four researchers specialized in public health and epidemiology (XM, MTA, MM, and MHA) conducted a comprehensive literature search following the stages recommended by the JBI [13].

Firstly, an initial pilot study search was conducted in PubMed (MHA and AJ) using keywords and Medical Subject Headings (MeSH) terms associated with "elderly," "frail," "senior," "frail elderly," "digital health," "e-Health," "telemedicine," "telehealth," "digital therapeutics," "virtual medicine," "information and communication technology," "ICT," "silver economy," "mhealth," "mobile application." In this study, MeSH terms were not used in the final search as they did not effectively discriminate between relevant and non-relevant articles. Instead, free terms were utilized in the titles and abstracts of the documents, allowing for a more precise and targeted search. This approach detected a broader range of relevant studies and sought to ensure no pertinent research was overlooked. Using free terms refined the search criteria to better match the specific context and nuances of the research focus.

The search strategy was implemented across additional databases to ensure the results aligned consistently with the research question. Subsequently, the keywords identified from the relevant articles in the initial search were utilized to formulate a comprehensive and planned search strategy (**Appendix** search strategy).

A language filter was applied to include documents in English, French, Portuguese, and Spanish, and only studies in humans were included. There was no restriction by publication year. Finally, a review of the references of the included documents was conducted.

The search was conducted from 4 to 15 April 2022, for indexed literature, and 25 April to 26 May 2022, for grey literature and hand search. Reference management software was used to organize the reference database. Additionally, the search results were managed in Microsoft Excel v.2108, with separate sheets created for the search and review processes.

The titles and abstracts of the documents obtained from the identification phase were screened, selecting those to be reviewed in full text during the eligibility phase. Each document, at both stages, was reviewed by two independent researchers, and disagreements were resolved by a third reviewer, all from the research team (IM, CCL, AJ, CA, AO, PR, XM, MM, MHA, OU, TA, FS, and SE). Most of the reviewers have extensive experience in public health research, epidemiology, and literature reviews.

Full text was searched through open access, by requesting assistance from the Biomedical Library of our university or asking directly from the authors. The entire selection process was diagrammed in a flow chart identifying each stage (identification, screening, and eligibility) (**Figure 1**).

Data Extraction

Data extraction from the selected studies followed the methodology outlined by Peters et al. [13]. The research team initially piloted and implemented the extraction process, testing the designed matrix and refining it based on received feedback. This approach facilitated the standardization of criteria for the final data extraction. Upon completion, six researchers (CCL, CA, AO, XM, IM, MHA) reviewed this phase, validating the information extracted from the documents and adjusting as needed.

Data were compiled in a single spreadsheet (**Supplementary Material**), containing the articles' main characteristics, along with specific aspects of the review question. Data extraction categories included a detailed overview of each study's bibliographic information, context, objectives, research design, outcomes, and key findings related to this scoping review [10]. To classify digital health interventions, the WHO's classification of interventions, services, and applications in health was used [14], and was considered those aimed at person and healthcare providers. Three stages were considered for the level of technological development: *conceptualization and design* (focus on the generation and initial formulation of the intervention, ranging from the initial idea to the design of a functional prototype), *testing and validation* (includes pilot tests and clinical evaluations aimed at testing the intervention in controlled settings or with small groups to validate its efficacy, usability, and safety), and *implementation and scaling* (cover both small and large-scale implementation, commercialization, and post-implementation evaluation, focusing on bringing the intervention into wider use and evaluating its impact and effectiveness in real-world, long-term settings) [15].

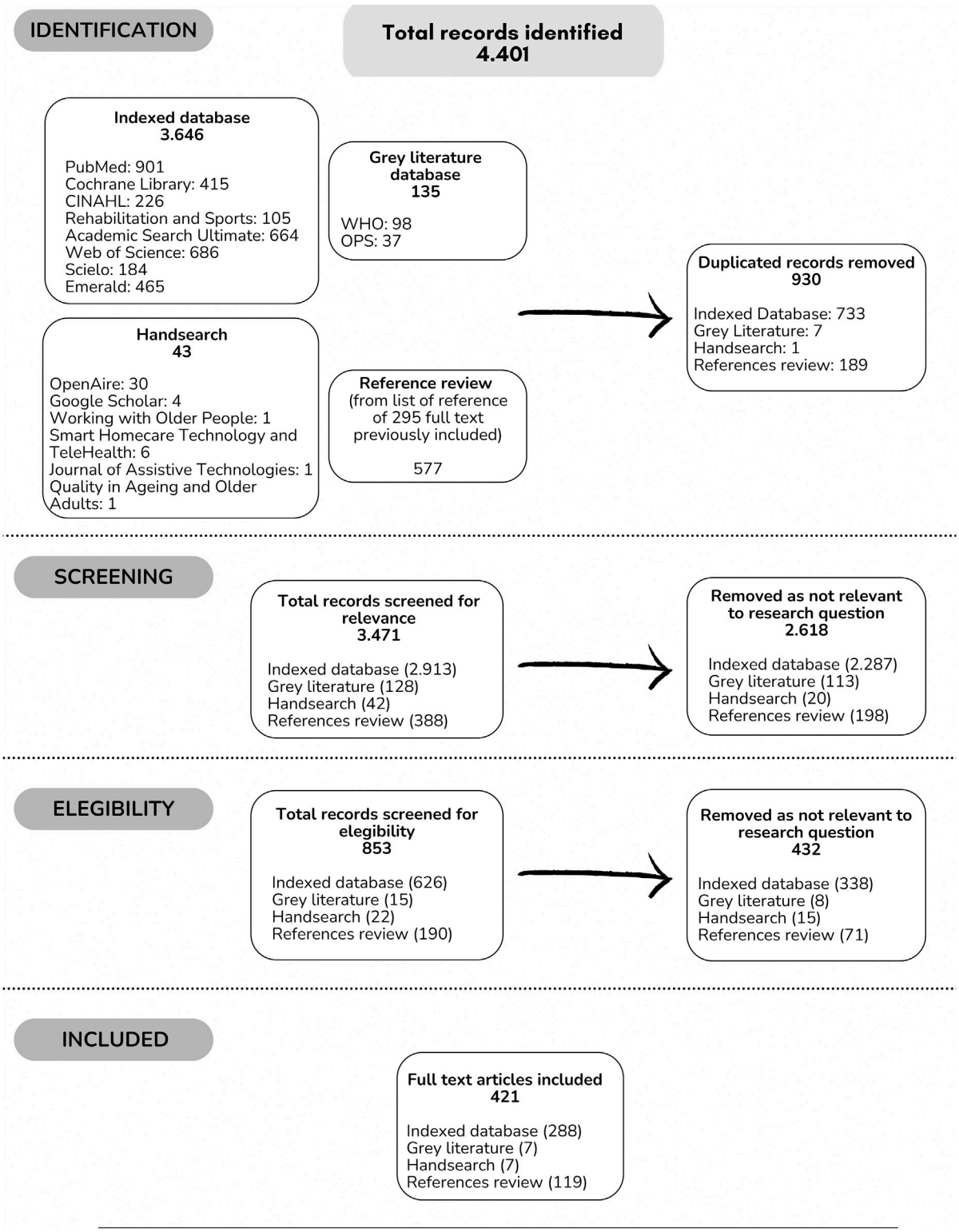

FIGURE 1 | Flowchart of study selection according to scoping review process (Worldwide, 2022).

TABLE 1 | Summary of characteristics of the included documents (Worldwide, 2022).

Characteristic of included documents (n = 421)*		
Characteristic	**N**	**%**
Publication year		
1988–2002	13	3.1
2003–2007	33	7.8
2008–2012	86	20.4
2013–2017	136	32.3
2018–2022	153	36.3
Publication type		
Indexed (n = 411)		
Research article	398	96.8
Congress abstract	8	1.9
Poster	1	0.2
PhD thesis	1	0.2
Special communication	2	0.5
Dissertation	1	0.2
Grey literature (n = 10)		
Technical report	6	60.0
Recommendations	2	20.0
Country report	1	10.0
Position paper	1	10.0
Study design (n = 411)		
Clinical trials, Experimental and Quasi experimental	210	51.1
Report, review or discussion article	33	8.0
Systematic review (with or without metanalisis) and scoping review	27	6.6
Case series	26	6.3
Cross-sectional study	25	6.1
Literature review or Narrative review	25	6.1
Cohort study	17	4.1
Mixed method	15	3.6
Qualitative study	12	2.9
Case-control study	9	2.2
Observational not specified	6	1.5
Other[a]	6	1.5
Corresponding author sex (n = 411)		
Female	194	47.2
Male	217	52.8

*[3, 4, 16–434].

[a]Indexed articles that could not be classified such as: based case management, retrospective descriptive study, technology model User-Centred Design, assistive technology project.

Analysis and Presentation of Results

Data from the selected studies and documents were synthesized by four researchers (CCL, CA, XM, MHA) through an iterative process, according to the research question.

RESULTS

Overview

A total of 4,401 records were identified, obtaining 3,471 (78.8%) after eliminating duplicates. Those 3,471 were reviewed in title and abstract (screening). Of them, 853 (24.6%) were selected to continue with the full-text review (eligibility). Finally, 421 (49.4%) documents were included in the analysis and came from: indexed databases 288 (68.4%); grey literature 7 (1.7%); hand search 7 (1.7%) and references review 119 (28.3%) [3, 4, 16–434].

When categorized according to indexed articles or grey literature, 97.6% (n = 411) and 2.4% (n = 10) were identified, respectively. Documents published from 1988 to 2022 (the year the review was in progress), with almost 90% of the publications since 2008 (**Table 1**).

For the 411 indexed articles, the sex of the corresponding author and the study design were recorded. Grey literature was excluded from this analysis due to the nature of the authorships and the type of scientific communication. In this regard, it was found that 47.3% (n = 194) of the corresponding authors were female. About the study design, 51.1% (n = 210) were clinical trials or experimental and 20.2% (n = 83) were observational (**Table 1**).

Population

The interventions were primarily aimed at the elderly population (93.3%, n = 393), followed by healthcare professionals (48.0%, n = 202), and caregivers (43.0%, n = 179). Among the interventions focused on caregivers, the most studied group were family or informal caregivers (40.8%, n = 73) (**Table 2**).

Twenty documents focused exclusively on interventions for healthcare professionals. These interventions included teleophthalmology, emergency triage, cognitive assessments and development of technologies for care and tele-rehabilitation systems. Other areas addressed include reducing emergency admissions, using wearable devices for health monitoring, supporting caregivers with digital tools, and adapting tele-neuropsychology for the COVID-19 pandemic.

Only five documents focused specifically on caregivers. These studies examined the effectiveness of a platform to enhance caregiver competence, satisfaction, and coping abilities, identified mobile apps for caregivers, and outlined best practices from successful interventions. They also analyzed psychosocial interventions using technology, examined web-based interventions, focusing on their development, delivery, and impact on caregiver health outcomes. Additionally, they explored how technology can improve caregivers' quality of life.

Chronic diseases were the most studied condition, accounting for 51.8% (n = 218) of the total, with hypertension, diabetes, obesity, chronic obstructive pulmonary disease, chronic pain, and joint issues being the most common. Fragility-related issues, including low grip strength, falls, and balance disorders, were the focus of 27.1% (n = 114) of studies. Neurological conditions, such as Alzheimer's and dementia were examined in 24.0% (n = 101) of the cases. Mental health including depression, anxiety, social isolation, and loneliness comprised 17.8% (n = 75). Studies on healthy ageing and quality of life made up 13.1% (n = 55) of the total. Less than 2% of the studies focused on sensory impairment and infectious disease, respectively (**Table 2**).

Other conditions were accounted for in 5.0% (n = 21) of the studies and were related to medication problems, acute illnesses, nutrition and dietary status, specific pathologies, medical and hospital care, health awareness and education.

Context

The studied countries classified by income and region according to the World Bank [435], are presented in **Table 2**. Of the total of

TABLE 2 | Summary of characteristics of included documents according to PCC model (Population, Context, Concept) (Worldwide, 2022).

Characteristic of included documents (n = 421)*		
Characteristic	**N**	**%**
Population		
Elderly	393	93.3
Healthcare professionals	202	48.0
Caregivers		
Family/Informal	73	17.3
Formal	52	12.4
Not specified	54	12.8
Disease or condition		
Chronic disease (hypertension, diabetes, cancer, obesity, chronic obstructive pulmonary disease, chronic pain, musculoskeletal, etc.)	218	51.8
Fragility (low grip strength, falls, balance disorders, etc.)	114	27.1
Neurological (Alzheimer's, dementia, etc.)	101	24.0
Mental health (depression, anxiety, social isolation, loneliness, etc.)	75	17.8
Healthy ageing and quality of life	55	13.1
Other[a]	21	5.0
Sensory impairment	8	1.9
Infectious disease	6	1.4
Context		
Region of Country (World Bank Region)		
Europe and Central Asia	149	35.4
North America	114	27.1
East Asia and Pacific	78	18.5
Other[b]	22	5.2
Middle East and North Africa	6	1.4
Latin America and the Caribbean	5	1.2
Sub-Saharan Africa	3	0.7
South Asia	1	0.2
Worldwide	39	9.3
Not specified	4	1.0
Income of Country (World Bank Income)		
High	337	80.0
Upper-middle	28	6.7
Lower-middle	4	1.0
Low	1	0.2
Other[c]	8	1.9
Worldwide	39	9.3
Not specified	4	1.0
Setting		
Home	320	76.0
Nursing home (Retirement home, Community care Veterans' home, Senior living centers, Day care)	120	28.5
Healthcare facility	111	26.4
Other[d]	13	3.1
Healthcare level (n = 111)		
Primary	71	64.0
Secondary	61	55.0
Tertiary	53	47.7
Concept		
Health objective of the digital tool		
Monitoring or follow-up	265	62.9
Prevention	201	47.7
Therapy or treatment	200	47.5
Promotion	86	20.4
Diagnosis	80	19.0
Rehabilitation	70	16.6
Digital health interventions for persons		
Targeted communication to Persons	259	61.5
Personal health tracking	190	45.1
On demand communication with persons	97	23.0
Person to Person communication	81	19.2
Other[e]	38	9.0
Digital health interventions for healthcare providers		
Telemedicine	239	56.8
Healthcare provider decision support	200	47.5

(Continued on following page)

TABLE 2 | (*Continued*) Summary of characteristics of included documents according to PCC model (Population, Context, Concept) (Worldwide, 2022).

Characteristic of included documents (n = 421)*		
Characteristic	**N**	**%**
Prescription and medication management	113	26.8
Referral coordination	78	18.5
Other[f]	13	3.1
Healthcare technologies results		
Positive	366	86.9
No differences	36	8.6
Partially positive	11	2.6
Negative	8	1.9
Type of digital health tools		
Hardware or physical devices		
Telephone (cell phone, smart phone, landline phone)	216	51.3
Desktop or laptop computer	166	39.4
Wearable activity monitors (wrist-worn devices, or step counters)	98	23.3
Tablet	91	21.6
Sensors and positioning system	89	21.1
Video game consoles, exergames, balance board, dance mat, handheld remotes, fitness board, buzz controller, force platforms, cameras with gesture recognition, virtual environment non-immersive and immersive	55	13.1
Telehealth devices (with or without health measurement)	50	11.9
Other[g]	37	8.8
Interactive TV	34	8.1
Robots, social robots, robotic rollators, industrial and service robots, assistive telepresence robot	11	2.6
Radio RX/TX with interaction	2	0.5
Software, platforms		
Videoconference platforms	153	36.3
Text/Audio Messaging (SMS, Chat, etc.)	110	26.1
Digital health portals	91	21.6
Health and fitness apps	81	19.2
Video game	63	15.0
Electronic mail	50	11.9
Digital community or groups	35	8.3
Other[h]	34	8.1

*[3, 4, 16–434].

[a]*Medication problems, acute illnesses, nutrition and dietary status, specific pathologies, medical and hospital care, and health awareness and education.*

[b]*Combination of region.*

[c]*Combination of high/upper-middle and high/upper-middle/lower middle.*

[d]*Public transportation, hospital at home, community centers, day care center, university, outpatient rehabilitation sports club, welfare centers, Aware Home Research Initiative (AHRI) at the Georgia Institute of Technology is a facility designed to facilitate research, while providing an authentic home environment.*

[e]*Digital therapeutics based on: therapies based on virtual technology and games, home-based exercise and rehabilitation programs, guided and personalized therapies, interventions based on robotics, emotional support and communication, medical devices and telemedicine applications.*

[f]*Healthcare provider training, Healthcare provider communication, Person-centered health records, Laboratory and Diagnostics Imaging Management, Scheduling and activity planning for healthcare providers, Person-Centered Health Records, Professional advisory roles.*

[g]*Communication Devices, Recording Devices and Cameras, Emergency and Alarm Systems, Reminders, Virtual and Augmented Reality Devices, Storage and Playback Devices, Personal Devices.*

[h]*Records and data management software or platforms, interactive and cognitive assistants, telephone services, websites and online platforms, exercise and educational content.*

421 records, it was possible to classify 378 documents (89.8%), the rest did not specify countries (1.0%, n = 4) or referred to the world level (9.3%, n = 39).

When analyzing income, 80.0% (n = 337) were from high-income countries (HIC), 6.7% (n = 28) from upper-middle-income economies (UMIC), 1.0% (n = 4) from lower-middle-income (LMIC), and only 0.2% (n = 1) from low-income countries (LIC). A 1.9% (n = 8) were a combination of high/upper-middle and high/upper-middle/lower middle.

The most studied regions, accounting for 62.5%, with Europe and Central Asia (35.4%, n = 149), and North America (27.1%, n = 114), followed by East Asia and Pacific (18.5%, n = 78).

It was also studied whether the technology was applied at home, in care centers and residences for the elderly, healthcare facilities or other places. It was found that 76,0% (n = 320) declared a home context, 28.5% (n = 120) care centers and residences for the elderly, 26.4% (n = 111) healthcare facilities and 3.1% (n = 13) others (public transportation, hospital at home, community centers, university, outpatient rehabilitation sports club, welfare centers and a facility designed to research providing an authentic home environment).

Of those who studied a healthcare facility (n = 111), it was found that the level of healthcare corresponded to 64.0% (n = 71) primary, 55.0% (n = 61) secondary and 47.7% (n = 53) tertiary.

Concept

Despite the diverse methodologies and study designs in the reviewed documents, the reported results related to the use of

healthcare technologies were predominantly positive (86.9%, n = 366). Additionally, 11% (n = 47) reported no differences or partially positive results, and only 1.9% (n = 8) negative results (**Table 2**).

When analyzing the level of technological development, 97.4% (n = 410) of the documents indicated some level. Specifically, 18.8% (n = 79) were at the conceptualization and design stage, 69.1% (n = 291) were in testing and validation, and 25.9% (n = 109) were in the implementation and scalability stage. Documents reporting multiple levels of development were mostly reviews (**Table 2**).

In relation to the health objective sought by the technological tool, it was found that 62.9% (n = 265) addressed monitoring/follow-up; 47.7% (n = 201) prevention; 47.5% (n = 221) treatment; 20.4% (n = 86) promotion; 19.0% (n = 80) diagnosis, and 16.6% (n = 70) rehabilitation (**Table 2**).

By classifying digital health interventions, services, and applications in health, of the 421 documents, 61.5% (n = 259) focused on targeted communication to persons; 45.1% (n = 190) on personal health tracking; 23.0% (n = 97) on demand communication with persons; 19.2% (n = 81) on person-to-person communication; and 9.0% (n = 38) on other categories. This last category includes digital therapeutics based on virtual technology and games, home-based exercise and rehabilitation programs, guided and personalized therapies, interventions based on robotics, emotional support and communication, and medical devices and telemedicine applications. Of those interventions aimed at healthcare providers, 56.8% (n = 239) were related to telemedicine; 47.5% (n = 200) to healthcare provider decision support; 26.8% (n = 113) to prescription and medication management; 18.5% (n = 78) to referral coordination and 3.1% (n = 13) to other classifications. The latter category considered healthcare provider training, healthcare provider communication, person-centered health records, laboratory and diagnostics imaging management, scheduling and activity planning for healthcare providers, person-centered health records, professional advisory roles (**Table 2**).

The type of technology related to hardware and software was analyzed. Regarding hardware, 51.3% (n = 216) referred to telephone (cell phone, smart phone, landline phone); 39.4% (n = 166) to desktop or laptop computer; similar proportions (close to 20%) were found for wearables (wrist-worn devices or step counters); Tablet and sensors and positioning system. Less than 15% was found for video game consoles (exergames, balance board, dance mat), interactive TV, robots (social robots, robotic rollators, assistive telepresence robot), and radio RX/TX with interaction. Telehealth devices (with or without health measurement) were found on 11.9% (n = 50). On the other category was found communication and recording devices, cameras, emergency and alarm systems, reminders, storage and playback devices (**Table 2**).

In terms of software, it was found that the most widely used was videoconference platforms with 36.6% (n = 153); followed by text/audio messaging with 26.1% (n = 110); digital health portals with 21.6% (n = 91), and less than 20% each of the following: health and fitness apps, video games, email, and digital community or groups. In the other category was found records and data management software or platforms interactive and cognitive assistants telephone services websites and online platforms, exercise and educational content (**Table 2**).

In relation to the health objective and the condition under study, for chronic diseases, the most prevalent objective was treatment (76.1%), for fragility was prevention (63.2%), whereas for infectious diseases, it is monitoring/follow-up (83.3%). Meanwhile, prevention and monitoring/follow-up highlight their primary objective in the case of healthy aging and quality of life (69.1% and 60.0%, respectively). The category named other is not described due to the diversity of situations. **Figure 2**.

When the year of publication and type of device studied were analyzed (**Figure 3**), it was found that over the years, there is a

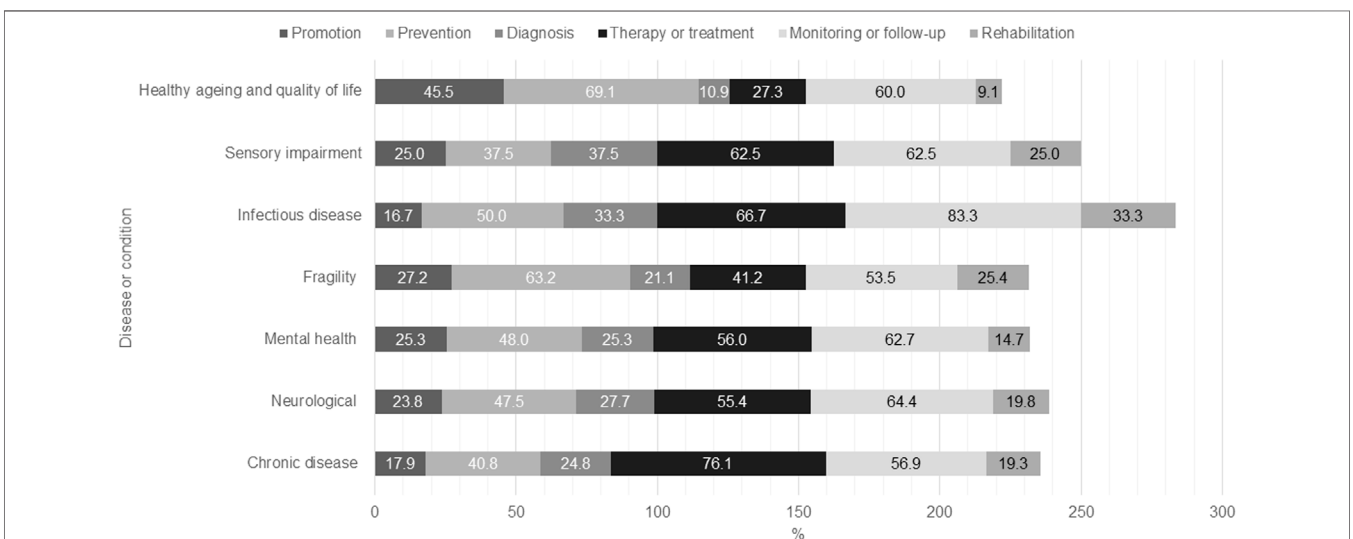

FIGURE 2 | Summary of characteristics of included documents according to Population, Context, Concept (PCC) model (Worldwide, 2022).

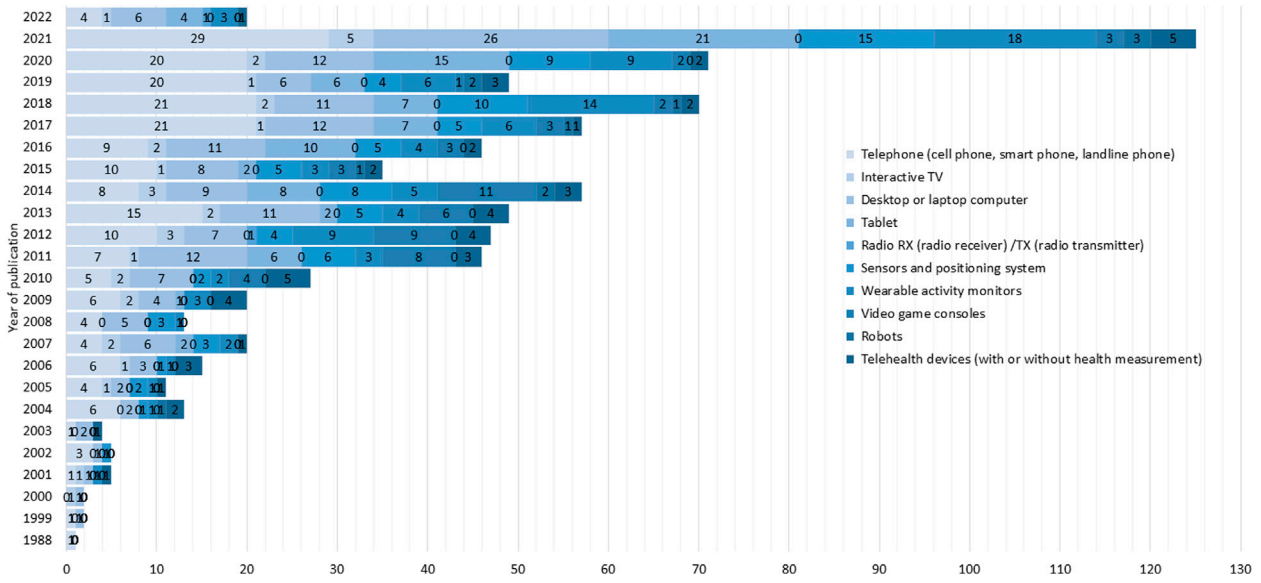

FIGURE 3 | Number of documents by year of publication and type of device studied (Worldwide, 2022).

noticeable increase in the use of telephones, especially in the recent period from 2020 to 2022, suggesting a massive adoption of this technology in the analyzed studies (mostly driven by cell phone and smartphone). The use of desktop or laptop computers remains constant over the years, with significant peaks around 2011 and 2022. Activity monitors and sensors show an increasing trend from 2010 onwards, indicating a rise in the analysis of these technologies, particularly in the years 2015, 2017, and 2021. There is a sustained use of telehealth devices over the years, with a notable increase in 2022, possibly reflecting the response to the COVID-19 pandemic and the need for remote health solutions.

Figure 4 illustrates the utilization of various technological devices across different health objectives, including promotion, prevention, diagnosis, treatment, monitoring/follow-up, and rehabilitation. Telephones and computers are the most used devices for all health objectives analyzed. However, in the case of promotion, video game consoles (31.4%) and wearables (27.9%) also have a significant presence. For prevention and diagnosis, sensors and positioning systems (32.8% and 28.8%, respectively) and wearables (26.4% and 28.8%, respectively) are also prominent. In the case of therapy or treatment, Tablets rank third (26.0%). For monitoring/follow-up, wearable activity monitors (31.3%) and sensors and positioning systems (25.3%) are also considered important, and finally, for rehabilitation, interactive TV (22.9%) is significant. Overall, the figure highlights the diverse roles of these devices in healthcare, with some being more versatile and widely used across multiple functions.

The frequency and distribution of technological devices across multiple diseases, highlights the prominent role of telephones and computers. The data reveals that these devices are extensively used to address chronic diseases (62.8% and 42.2%, respectively), fragility (46.5% and 43.0%) and mental health issues (64.0% and 46.7%). Infectious diseases show same proportion for telephones, computers and Tablets (50.0%, each one). Additionally, telephones show the highest usage for sensory impairments (87.5%). Tablets, wearables and sensors also play a vital role, particularly in neurological conditions (30.7%, 20.8%, and 21.8%) and healthy aging (20.0%, 20.0%, and 25.5%).

DISCUSSION

There has been an exponential increase in the number of publications on digital health and elderly in recent years. Interventions mainly targeted older adults and healthcare professionals, focusing on chronic conditions, frailty, and neurological diseases. Most studies originated from high-income countries, primarily in Europe and Central Asia, with home being the main application context. Technological development was mostly in the testing and validation stages, with fewer in implementation and scalability. The main objectives were monitoring/follow-up, prevention, and treatment. Interventions focused on directed communication and personal health monitoring for individuals, and telemedicine and decision support for healthcare providers. Throughout the period analyzed, telephones and computers were the most used devices, with videoconferencing and text/audio messaging being the most common software. Over the past decade, there has been an increase in the study of wearables, sensors and positioning systems, and a significant rise in telemedicine in 2022, likely due to the COVID-19 pandemic, highlighting the growing adoption of health technologies and positive trends in reported outcomes.

By 2050, 80% of older people will be living in low- and middle-income countries [1]. Despite this, this study found that most technologies designed to assist the elderly are developed and tested in high-income countries. To enhance access to health

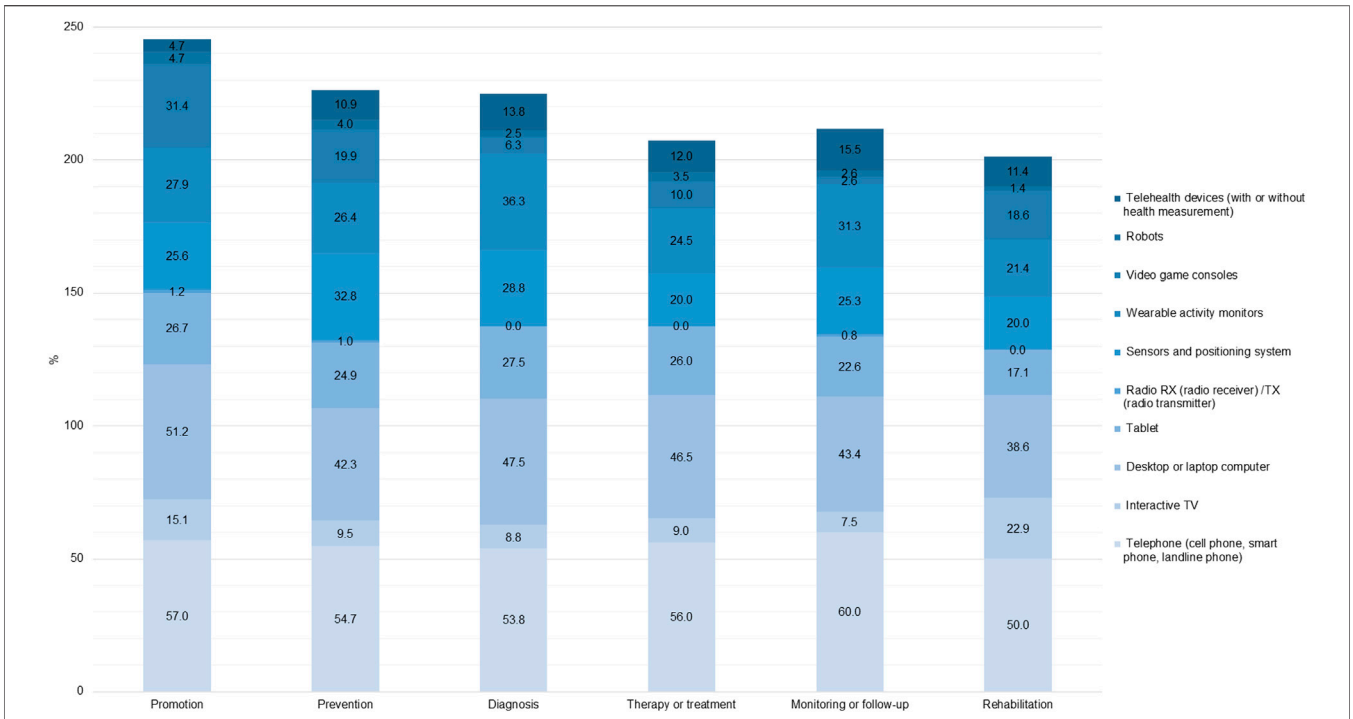

FIGURE 4 | Proportion of documents by health objective and hardware (Worldwide, 2022).

services for the elderly, it is important to ensure that these technological solutions are available and accessible where most of this population will reside.

An interesting finding were the context in which the studies were conducted, with 76% stating home as their setting, well above healthcare facilities or elderly residences. This aligns closely with older adults' preferences to stay in their own homes for as long as possible [436, 437]. In this context, digital health, such as receiving remote care, and preparing homes as smart homes, can become a significant ally in supporting elderly to remain in their homes, helping live as independently as possible.

Most documents indicated some level of development, specifically, in testing and validation. These findings suggest a robust pipeline of technological innovations but also raise questions about their maturity and evaluation. The predominance of projects in the testing and validation phase implies many innovations are still in their early stages and may not have demonstrated efficacy in long-term, real-world environments. This focus on early stages suggests a landscape where technologies are frequently conceptualized and prototyped, but fewer are rigorously evaluated and scaled. It is essential to scrutinize whether these technologies are primarily tested with commercial intentions without thorough evaluations of their long-term impact and effectiveness. Moving forward, it is crucial to emphasize comprehensive evaluation and scalability to ensure technological advancements transition from promising prototypes to impactful solutions that withstand real-world application.

One of the key findings is the high number of interventions targeting chronic diseases focusing on treatment. This indicates a strong emphasis on managing long-term conditions through continuous treatment and monitoring, showcasing the potential of technology to support chronic disease management effectively. For neurological diseases, documents emphasize monitoring/follow-up. This suggests a critical role for technology in tracking disease progression and patient status, which is essential for conditions that require constant observation and timely intervention. Mental health conditions showed a similar trend, focusing on monitoring/follow-up. This highlights the importance of sustained surveillance in mental health to provide timely support and intervention, reflecting the need for persistent engagement and assessment in mental healthcare. When examining interventions for fragility conditions, most documents aimed at prevention. This underscores the proactive approach necessary in addressing issues related to frailty, emphasizing the role of technology in preventing falls, improving balance, and maintaining overall health among the elderly. In the same way, healthy aging and quality of life are more related to prevention, highlights the potential of technology to enhance the quality of life and health outcomes for the aging population, aiming to delay the onset of age-related issues and promote wellness. In any case, all the conditions studied show, to a greater or lesser extent, potential for the use of digital technologies for each of the health objectives. This diversity indicates the multifaceted role of technology in managing any condition, from early detection to comprehensive care and education.

Digital health interventions aimed at treatments, including virtual reality, images, videos, and app prescriptions, do not currently have a corresponding category within the existing WHO framework [14]. However, for those digital

interventions with a therapeutic purpose, this classification might need to be reviewed to include a category or type of application or system related to this purpose, likely within the "Services and Application Types" section. Including such a category or type dimension would enhance our understanding of digital health applications' scope and highlight the potential of emerging technologies to address health treatment and management challenges more effectively with innovative and patient-centered solutions. We have submitted this proposal to WHO through the respective form.

It is important to consider the increasing integration of technology in elderly daily lives, recognizing the growing familiarity and comfort of the aging population with technological tools. As today's older adults have a greater proficiency with technology, their use of digital health interventions is expected to continue rising [438]. This shift presents opportunities to enhance health outcomes through personalized, accessible, and efficient care. However, it also underscores the need for tailored solutions that address the unique needs and preferences of older adults, ensuring that digital health tools are user-friendly and effectively support their health and wellbeing. Healthcare systems will increasingly need to consider these findings to design and implement effective digital health policies for older adults, overcoming various barriers to accessing healthcare services and digital health for this population group.

The evidence in this area is expanding quickly, not only thanks to rapid advances in technology, but also due to the global aging population and a rising interest in meeting the health and quality-of-life needs of elderly. There is very recent literature on this topic [439–441]; however, these studies primarily focus on specific conditions or isolated contexts. In contrast, this review offers a comprehensive approach, while addressing a wide range of technologies, health conditions and diverse contexts for older adults and their caregivers. This broader scope offers a more comprehensive understanding, addressing key gaps in the existing body of research and providing a crucial foundation for designing interventions and strategies that effectively respond to the complex and interconnected needs of these populations.

However, this study has limitations. Since assessing the quality of the evidence is optional in this type of reviews, low-quality studies are not identified. Detailed information on types of telephones and caregivers was also lacking due to incomplete data in the documents. Additionally, the impact of age is an aspect that warrants special consideration, as it helps to explain the growing number of studies in this area. Elderly individuals are increasingly becoming familiar with technology, which reflects an important shift in their interaction with digital health solutions. Few publications exclusively address caregivers of elderly, even though globally, many people provide care for family members with chronic illnesses, disabilities, or aging-related needs. High-income regions, despite having more developed and institutionalized care systems, also rely on family caregivers [442, 443]. A study found that over 50% of elderly (OECD countries) preferred family care over formal help, influenced by socioeconomic level and cultural values [444]. In Latin America and the Caribbean, the caregiving burden is especially significant, with family members, particularly women, shouldering most responsibilities, often involving extensive unpaid work. This demanding role often results in high levels of stress, burnout, and health issues among caregivers, underscoring the urgent need for enhanced support and resources tailored to family caregivers in these regions [445].

Finally, the high proportion of documents presenting positive results (86.9%), is consistent with the literature trend where positive results are much more represented than negative ones, indicating a potential publication bias [446]. This, among other issues related to underreporting negative results, introduces bias in analyses and misinforms researchers and, consequently, decision-makers.

Conclusion

Increasing integration of technology in older adults' lives, along with their increasing proficiency, is driving a significant rise in digital health interventions. Despite this growth, further research in middle- and low-income countries, for caregivers and evaluating effectiveness and feasibility of these technological interventions is needed. The future of digital health for elderly population, caregivers and healthcare professionals presents challenges that must be addressed to realize its full potential. One major issue is accessibility, as these technologies evolve it will be essential ensuring that they are user-friendly and inclusive for all older adults, regardless of their technical skills. Data privacy and security also become critical concerns as more personal health information is shared through digital platforms, demanding robust protections to build and maintain trust among users. Additionally, healthcare providers will face the challenge of integrating digital health tools effectively within traditional care settings, which may require new training and adaptation to evolving workflows. Finally, supporting caregivers and family members in adopting these technologies could be complex, as they often have diverse needs and limited time. Addressing these challenges will be key to harnessing the power of digital health to improve care and quality of life for aging populations.

AUTHOR CONTRIBUTIONS

Conceptualization: AJ, MM, XM, and MH-A; Search: AJ, MM, MH-A, XM, and MT-A; Selection: AJ, AO, XM, MH-A, IM, CC-L, CA, PR, OU, TA, FS, and SE; Extraction: AO, CA, CC-L, MH-A, PR, OU, FS, and XM. Manuscript: AO, AJ, MM, MH-A, IM, CC-L, CA, TA, FS, SE, PR, MT-A, OU, and XM. All authors contributed to the article and approved the submitted version.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.ssph-journal.org/articles/10.3389/phrs.2024.1607756/full#supplementary-material

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APPENDIX: SEARCH STRATEGY

Database: PubMed (The strategy created for PubMed was modified to suit the requirements of the other databases.)

Date: 06 April 2022.

Key words: elderly OR frail OR senior OR frail elderly.

AND

digital health OR e-Health OR telemedicine OR telehealth OR digital therapeutics OR virtual medicine OR information and communication technology OR ICT OR silver economy OR mhealth OR mobile application.

Filters: humans and languages (English, French, Portuguese, Spanish)

Strategy:

("elderly"[Title/Abstract] OR "frail"[Title/Abstract] OR "senior"[Title/Abstract] OR "frail elderly"[Title/Abstract]) AND ("digital health"[Title/Abstract] OR "e-Health"[Title/Abstract] OR "telemedicine"[Title/Abstract] OR "telehealth"[Title/Abstract] OR "digital therapeutics"[Title/Abstract] OR "virtual medicine"[Title/Abstract] OR "ICT"[Title/Abstract] OR "Information and Communication Technology" OR "silver economy"[Title/Abstract] OR "mhealth"[Title/Abstract] OR "mobile application"[Title/Abstract])