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Navigating the gerontechnological frontier: Innovations and challenges in the care field

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Abstract

Background: In the coming decades, the population of individuals aged 65 and above is projected to experience a notable surge. This demographic transition demands novel approaches to improve and transform elder care practices using emerging gerontechnologies.
Objective: This article presents a comprehensive analysis of the gerontechnology domain and its applications in elderly care. Furthermore, it aims to improve understanding in the care field and promote the advancement of elder care by utilizing evidence-based strategies and identifying research priorities.
Method: This article is based on a systematic review of the literature published between January 2022 and December 2023, which was conducted by employing the PRISMA methodology, and reputable databases such as PsycInfo, PubMed, IEEE Xplore, and CINAHL were used to compile the data.
Results: This research aims to categorize existing technologies to reveal a diverse array of products and technologies to address the distinct needs of the elderly. Their implementation within the care sector is given particular attention in order to emphasize innovative approaches to enhance the quality of senior care. Moreover, the research highlights the current scientific challenges, limitations and research gaps in the development and integration of advanced technologies that are observed within the field of gerontechnology. This enables the researchers to improve the existing knowledge of the field and offers a comprehensive foundation for directing future research efforts and technological innovations.
Conclusion: This framework is intended to serve as a strategic guide for advancing the integration of emerging technologies into elder care practices. This paper provides valuable insights for researchers, practitioners, and policymakers by presenting a thorough analysis of the current state of gerontechnology. It highlights critical scientific challenges as well as strategic recommendations for addressing these issues.

Keywords: gerontechnology, assistive technology, care, nursing, elderly, aging

Introduction

The global demographic landscape is undergoing a tremendous transition, as seen by a significant increase in the aging population. This transition is particularly evident in numerous nations that are currently experiencing substantial demographic challenges. Japan possesses one of the greatest percentages of elderly citizens, with over 29,3% of its population aged 65 and above (Asahi Shimbun, 2023). Projections for 2050 indicate that around 41% reaching a total of 24 million of Germany's population will be aged 65 and older (World Health Organization, 2023). Italy is also experiencing a significant increase, with over 24,3% of its population being aged 65 or older (Statista, 2023). Likewise, South Korea is witnessing a swift rise in its old demographic, while Spain and the United Kingdom are encountering significant growth in their aging populations. In order to address this issue, effective policies and technological solutions must be developed and implemented, in addition to expanding and improving service delivery in order to meet the evolving needs of an aging population. The urgency of this challenge underscores the importance of targeted interventions to ensure that elderly individuals receive adequate support and care, thereby mitigating the impact of the care deficit and improving the quality of life for older adults across these and other affected nations (Ortman et.al., 2014). In light of these demographic challenges, gerontechnology has emerged as a crucial interdisciplinary domain that connects aging science with technological innovation. This domain includes a variety of advanced technologies designed to improve the well-being of senior persons by meeting their physical, cognitive, and social requirements. Notable developments encompass smart home systems, wearable health devices, remote monitoring technologies, and helpful robotics, all of which possess the capacity to profoundly alter eldercare practices. Integrating these tech-

nologies into caring frameworks can radically transform care delivery and enhance the independence, safety, and quality of life for elderly folks. This article examines the broad spectrum of solutions in the field of gerontechnology and attempts to systematically review and analyze the current state of the art. It explores the current state of technological interventions to support and improve the lives of older people. The focus of the study is on its use in the care sector. The period of in-depth contributions to the systematic review covers the last two years from January 1, 2022, to December 31, 2023. By focusing on the period from 2022 to 2023, this study aims to provide a clear overview of the current landscape of gerontechnology. This period is particularly notable as it includes the years directly succeeding the COVID-19 pandemic, during which the extensive integration of innovative technologies for aged care was notably influenced. The paper elucidates recent accomplishments and trends, demonstrating the pandemic's influence on the profession and underscoring the potential for future technological innovations. The aim is to conduct a thorough synthesis and analysis of the available evidence pertaining to the use of gerontechnologies in caring for elderly individuals in recent years, in order to achieve a comprehensive understanding regarding the conceptualization and systematization of gerontechnologies. By focusing on this specific period, we aim to clarify the current usage of gerontechnologies, providing information on the newest trends and potential for technologies to be developed in the future. This article addresses the pressing requirement to comprehend the state of gerontechnologies in the present, establishing a basis for discussion and tactical planning for improving elderly care through modern technological interventions.

The main objective of this paper is to examine the current limitations and gaps in the literature in order to contribute to the ongoing development and implementation of innovative technologies in elder care. Additionally, our main aim is to expand the understanding of gerontechnologies and facilitate future advancements in the field. This comprehensive approach will provide readers with valuable insights into gerontechnology and its potential to improve the quality of life for elderly individuals. Moreover, it serves as an overview of the current state of the art and a roadmap for overcoming scientific challenges in order to improve geriatric care.

Materials and methods

This systematic review significantly contributes to the continuing discourse on gerontechnology in elder care. It provides a comprehensive overview of the latest advancements and their practical applications in the field of care by examining usability and acceptance, as well as the problems faced during implementation. To the best of our knowledge, this systematic review represents a groundbreaking attempt to thoroughly examine a range of topics related to the most recent advancements in gerontechnology applied in the field of care. This systematic literature review focuses on the following research objectives:

- To systematically analyze the prevailing trends of gerontechnology in the older care field.
- To explore the usability and acceptance of these gerontechnological solutions.
- To identify and analyze the challenges related to the implementation of gerontechnological innovations in the field of care.

The systematic review protocol

Based on a systematic search across several databases, including PsycInfo, PubMed, IEEE Xplore, and CINAHL, a total of 52 publications spanning from January 1, 2022, to December 31, 2023, aligned with the review objectives and were considered for this research summary. The selection of these databases was influenced by their importance and significant contributions to the fields of aging, gerontechnology, and geriatrics. Using a combination of controlled vocabulary terms and keywords related to the nuances of the field of gerontechnology as described below, the search strategy ensures that a broad spectrum of potential studies was identified. Moreover, the review restricted the search query to the fields of title, abstract, and keywords in each database. The review specifically examined multiple overarching search terms, such as: (1) 'gerontechnology', (2) 'assistive technology', (4) smart technology', (3) 'care', and (4) 'nursing', (5) 'elderly', (6) 'Older adults', (7) 'Aging'. Although recent studies (e.g. literature reviews from 2022 & 2023) have examined the broad concept of 'technology', this study specifically concentrates on the term 'gerontechnology' to ensure that the selected publications specifically address innovations designed to aid older people. The inclusion of key terms in Web of Science for instance involved the use of Boolean operators.: (1) 'gerontechnology' OR 'assistive technology' OR 'smart technology' AND 'elderly care' OR 'Older adults care' OR 'Aging' (2) 'gerontechnology' OR 'assistive technology' OR 'smart technology' AND 'Older Adults Nursing' OR 'care' within the predefined time frame of the review (2022-2023).

In order to ensure the transparency and quality of reporting of this systematic review, the Preferred Reporting Items for Systematic Reviews

and Meta-Analyses (PRISMA) (Page et al., 2020) guidelines were followed throughout the review process. Since it provides a well-structured framework for conducting and reporting systematic reviews, ensuring a standardized and comprehensive approach, and also promotes transparency in documenting the review methodology, assisting the researchers and readers in comprehending the process of selecting studies, extracting data, and synthesizing evidence. By adhering to PRISMA guidelines (Page et al., 2021), this review aims to minimize bias, enhance reproducibility, and contribute to the robustness of the synthesized evidence in the field of gerontechnology in elderly care during the specified period (2022-2023).

Selection of the study

The original search yielded a total of 1,504 papers. The list was refined by eliminating duplicate entries, evaluating the remaining abstracts, and excluding publications that did not fulfill the specified inclusion and exclusion criteria *Table 1*, the total number of publications was reduced to 109. These publications were then subjected to an assessment of their full-text content to determine their eligibility. After completing this procedure, a total of 52 papers were selected for inclusion. *Figure 1* illustrates the search diagram and the number of articles evaluated at each level of the evaluation.

To adhere to scientific standards, unambiguous inclusion and exclusion criteria were defined to direct the process of study selection *Table 1*. The parameters covered specific aspects related to participants, exposures, comparators, outcomes, and study designs. Participants were

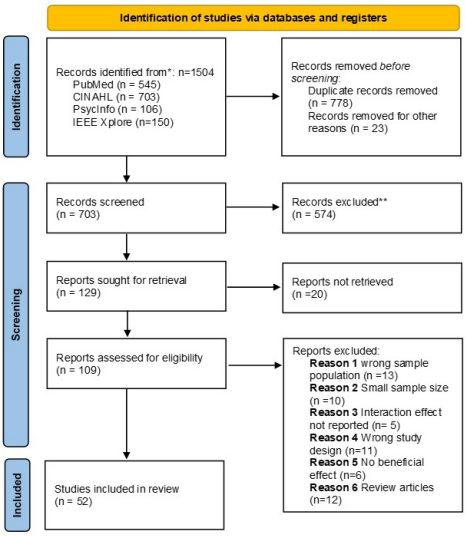

Figure 1. Data collection process visualized according to the PRISMA guidelines

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Peer-reviewed articles published in journals and conference proceedings.	Non peer-reviewed articles.
Studies that focused on the latest technological solutions in the elderly care.	Articles that propose an assistive technology not designed for older adults.
Studies that evaluate different trends of gerontechnologies in the care field.	Literature reviews and systematic reviews.
Articles that have user studies with seniors, who used, tested, experienced or provided perspectives on different assistive technologies.	Theses, book chapters, poster presentations and extended conference abstracts (due to limited information).
Articles that were published in the last two years.	Articles that were published prior to the past two years.
English language article.	Articles written in languages other than English.

selected based on relevant age and clinical criteria for gerontechnology interventions in the care sector. Technological applications were used to aid the care of older adults, and a range of interventions and exposures were included. Furthermore, this study encompassed empirical research that utilized qualitative, quantitative, or a combination of both approaches and was written or published in the English language. In addition, articles that specifically examined older individuals and/or caregivers as the subjects of the study were included. The study designs included randomized controlled trials, observational studies, and other empirical research methodologies.

In accordance with the specified inclusion criteria, the review disregarded research that specifically examined technology applicable to all populations. The review also omitted extended conference abstracts due to their limited information, as well as all types of publications of a non-academic nature and content sourced from online newspapers, social networks, and grey literature were excluded. Ultimately, articles composed in languages other than English were omitted. The systematic review sought to improve the reliability and validity of the synthesis evidence by explicitly defining criteria to guarantee the inclusion of research that adhered to stringent methodological standards.

Results

The domain of gerontechnology care is undergoing a substantial transformation due to the integration of caregiving and technology. Within

the diverse landscape of advancement, a central topic emerges: the exploration of technological trends in gerontological care. This exploration serves as a beacon, navigating us through the evolving terrain where innovation converges with the urgent needs of an expanding senior demographic. The recent search produced a conclusive compilation of 52 articles from journal publications and conference proceedings. *Figure 2* illustrates a word cloud created from the titles of these articles. The titles of the assessed articles primarily included the terms 'Technology', 'Robot', 'Assistive', and 'Older Adults', consistent with the study's emphasis and search criteria.

Figure 2. A word cloud depiction of reviewed articles

Figure 3 displays the authorial geography of the reviewed articles, with one entry per article regardless of the number of authors. It is important to acknowledge that the study was often carried out by researchers from many nations. In each instance, there was included one count in the graph for each country. The preponderance of the articles originated from scholars in the United States, Canada, India, with Japan, China, and Australia following suit.

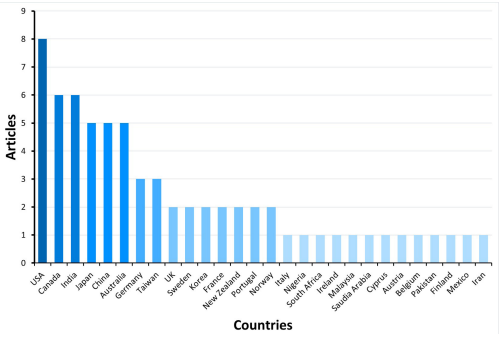

Figure 3. Authorial geography: A breakdown of the reviewed articles by country

In order to ascertain the present trajectory of gerontechnologies and their implications for supporting senior care and independent living, the chosen articles were examined in terms of their research objectives. *Figure 4* provides an overview of the main themes addressed in the

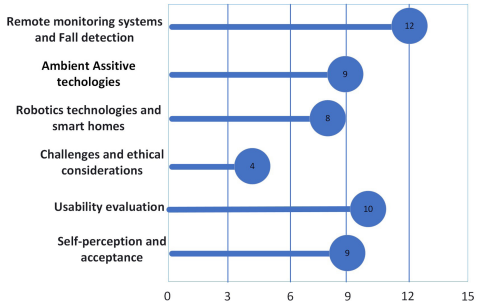

Figure 4. Analysis based on research subjects

evaluated articles. Out of the total of 52 articles, the largest number of them (n=12) were centered around remote monitoring and fall detection systems. The second highest number of articles (n=10) were focused on usability evaluation, followed by (n=9) self-perception and acceptance. Lastly, there were (n=9) articles that discussed ambient assistive living technologies, and eight (n=8) discussed robotics technologies and smart homes, where four (n=4) of the remaining publications focused on challenges and ethical considerations.

Evolving gerontechnology trends in elderly care

Building on the examination of recent literature, this section delves into the evolving trends in gerontechnology within the context of elderly care. By analyzing the distribution and focus of the identified studies, we can gain insights into the current advancements, emerging technologies, and the challenges shaping the future of elder care.

Overview

With the increasing number of elderly individuals in society, there is a growing interest in the intersection of technology and care for the elderly, which is being extensively studied by researchers. The dynamic field of gerontechnologies in the context of elderly care is a crucial area for scientific investigation, providing transformative opportunities to redefine and improve gerontological care. This analysis explores a wide range of gerontechnological trends, explaining their impacts and collectively presenting a detailed overview of their current direction. In the last two years, various technology innovations have emerged, promising to enhance the quality of care for elders and fundamentally alter the delivery of care. The analyzed trends encompass various advancements, including robotics technologies such as assistive, care, and social robots within smart homes, remote monitoring devices, fall detection systems, and other ambient assistive technologies, all of which enhance a more interconnected, efficient, and compassionate care framework.

Fall detection and remote monitoring systems

a. Fall detection systems

The growing incidence of falls among senior adults is a significant issue due to the considerable effects these accidents can have on their health and overall well-being (Lord & Dayhew, 2001). Incidents of falling can result in severe harm, diminished physical movement, and a deterioration in overall life satisfaction. Given the circumstances, the significance of fall detection systems becomes crucial (Kistler et al., 2018). Deploying dependable fall detection technology can have a pivotal impact on guaranteeing the safety of elderly individuals. These systems are designed to promptly identify and alert caretakers or emergency services in the event of a fall (De Raeve et al., 2022), facilitating timely intervention and potentially preventing further difficulties. By employing advanced technologies, we can enhance the care and support provided to the elderly, therefore promoting a safer and more secure environment for this vulnerable demographic. The development of new smart technologies and sensors that can retrieve different kinds of data from the platform has allowed researchers working on fall detection systems to make tremendous strides. Fall detection approaches are categorized into three main classes based on the type of sensors used: 1. ambient sensor-based which can analyze vibrations and noises by using pressure and vibration sensors that are placed in the floor or bed., 2. wearable sensor-based which utilizes specific devices attached to the human body to detect various changes in their activity where various wearable sensors, such as smart watches, accelerometers, or a combination of these, are used to detect or predict falls (Kulurkar, et al., 2023). 3. Finally, a vision-based technique capable of detecting falls through the use of many cameras or indicators.

These cameras are deployed in commonplace environments and gather comprehensive data on individuals and their actions. Visual-based device methodologies are progressively utilized in various contexts and numerous senior care establishments. Multiple vision sensors, including infrared sensors, RGB cameras, and depth sensors, have been used for fall detection (Denkovski et al., 2022). RGB cameras are a cost-effective and easily installed option for surveillance systems that are commonly used in everyday life.

b. Remote monitoring systems

The reviewed articles also highlighted a gerontological trend known as remote monitoring systems. These systems have become essential in contemporary healthcare and other sectors. They offer a versatile option for obtaining and evaluating real-time data. These technologies provide remote surveillance of equipment, processes, or humans, diminishing the need for physical proximity. Remote monitoring in healthcare allows healthcare professionals to track patients' vital signs, chronic diseases, or post-operative recovery from a centralized location, enhancing patient care regardless of geographical distance (Jafari et al., 2022). Remote monitoring technologies are essential in care facilities for safeguarding the well-being of residents (Devanathan, 2022). These systems extend beyond conventional monitoring, allowing healthcare providers to remotely assess patients' health metrics, thereby facilitating timely interventions and customized care plans (Ohashi et al., 2022). They also enhance the efficiency of care delivery through continuous monitoring of vital signs (Del-Vale-Soto et al., 2022) and other health parameters, including blood pressure, heart rate, and glucose levels (Bai et al., 2023). They also facilitate early detection of potential issues and promote a proactive and responsive healthcare approach within care facilities. As a result, the burden on caregivers is reduced.

Ambient assistive living technologies

The analyzed articles have identified an additional category of assistive technologies in the caregiving sector, primarily referred to as Ambient Assistive Living technologies. This category includes technological solutions designed to tackle diverse difficulties and improve the general well-being of elders. These technologies seek to enhance the autonomy and welfare of individuals, especially those with particular requirements or limitations, while they reside in their own homes. The "eSticky" remote reminder device for those in the initial phases of dementia is particularly notable among these innovations (Mettouris et al., 2023). This approach employs technology to deliver timely reminders, enhancing memory and daily activities. This not only enables timely intervention for potential health issues but also enhances the autonomy and security of senior adults in monitoring and responding to several facets of daily living, including health, safety, and general comfort.

Similarly, the voice-activated technology (Dalla Via, et al., 2022) has also been underscored as a potential assistive device for the elderly aging in place catering to their needs by supporting them with basic home-based commands such as turning On/Off TV, switching On/Off the light or locking the front door catering to the needs of older adults.

The wearable fabric tactile sensors (VG, et al., 2022) are another aspect of ambient assistive technology that employs a distinctive method of incorporating tactile feedback using affordable wearable conductive fabric. The FABTAC

sensors, incorporated into a 3D printed robotic hand (VG, et al., 2022), are intended to improve the safe and amicable interaction between robots and humans in a domestic home environment. These sensors provide instantaneous tactile feedback, enabling the robot to execute tasks such as grasping things and averting slippage. Thus, this novel technology possesses the capacity to automate daily tasks for the elderly, ultimately improving their overall quality of life. In the domain of physical assistance, advanced technologies typically include sensors, networking, or intelligent gadgets (Cerqueira et al., 2023). For instance, Internet of Things (IoT)-enabled smart canes (Adebiyi et al., 2022) employ these technologies to improve the daily lives of older folks by delivering real-time data and adaptive assistance. These systems aim to enhance safety, mobility, and the general quality of life for seniors via sophisticated monitoring and assistance functionalities. The incorporation of sensors into a smart cane allows this technology to detect abnormal gait patterns and tremors, providing essential insights into the ambulation of elderly individuals.

The "Handle Robot" represents an emerging concept in gerontology designed to provide physical assistance to elderly folks. The employment of robotic help in eldercare improves seniors' mobility and independence, showcasing the potential for aging in place (Bolli et al., 2023). Furthermore, the "Smart Walking Stick" (Zhu et al., 2022) integrates technology to assess the ambulation patterns of older folks and those with disabilities, with the objective of performing gait analysis and mitigating fall risks. A "Cane-Type Robot" (Moosavian et al., 2022) is designed specifically to mitigate falls, emphasizing the enhancement of user safety through electrical design. The "RoboWalk Assistive Device" represents a notable advancement aimed at the creation and evaluation of a mobility device intended to assist elderly individuals with locomotion challenges. It highlights the continuous endeavors to develop efficient solutions in assistive technologies. Finally, a "hand wearable grip assistive glove" (Wu et al., 2023) was specifically designed to mitigate hand muscle deficiencies in the older demographic. This underscores the importance of intuitive wearable devices in improving grip stability and mitigating accident risks. The aim of these technologies is to create a supportive and adaptable environment that promotes an improved quality of life, more autonomy, and personalized assistance for users, particularly in areas such as healthcare, aging in place, or disability support.

Robotic technologies and smart homes

The convergence of robotics technologies and smart homes has led to the development of inventive solutions designed to improve the welfare and overall quality of life for elderly individuals, and the field of care services is not an exception. The range of robots' practical applications is constantly expanding (Zhao et al., 2023). Care robots, for instance, are robots that are specifically designed to perform a variety of tasks in different domains, including physical assistance (e.g., lifting and mobility support) (Moosavian et al., 2022), social interaction (e.g., companionship and communication) (Lin et al., 2022), medication management (e.g., reminders and dispensing) (Turjamaa et al., 2023), and practical aid in daily activities (e.g., housekeeping and meal preparation) (Perotti & Strutz, 2023). They can operate either autonomously or semi-autonomously. The incorporation of care robots brings a human-centered aspect to gerontological care, broadening the scope of support through assisted recreation systems (Itai et al., 2022) that focus on overcoming operational difficulties in aged care facilities, emphasizing the potential of robotics to enhance recreational activities and overall well-being. According to recently reviewed articles, care robots have the capacity to offer companionship (Coghlan, 2022) and emotional support (Erel et al., 2022) through the utilization of robots that promote social interaction (Lin et al., 2022) among older individuals. This highlights the social dimension of robotics, demonstrating their function in promoting significant relationships and addressing social isolation among the elderly and further improves aging-in-place and independence in smart home environments (Zhou et al., 2023). This emerging field, supported by scientific research, represents a shift from traditional caregiving techniques. The development of a care robot equipped with an ethical sensing system (Kim et al., 2022) exemplifies a commitment to ethical considerations, ensuring a thoughtful integration of technology into the daily lives of old folks. The design of the easily upgradable, cost-effective autonomous assistive robot "ROSWITHA" (Sharan et al., 2022) underscores the need of flexibility and affordability in creating sustained robotic help for the elderly. Another type of robot spotted through the review was a mobile service robot (Odabasi, et al., 2022) whose primary function is to assist staff in elderly care homes by gathering empty water bottles from residents' rooms, transporting them to the kitchen, and returning refilled bottles, thereby streamlining routine logistical tasks and allowing staff to focus on meaningful interactions with the residents. This innovative trend exemplifies how robotics can tackle pragmatic, routine duties, thereby enhancing the safety

and efficacy of the living environment for seniors. Collectively, these instances demonstrate the wide-ranging uses of robotics in intelligent homes and residences, with the goal of establishing all-encompassing, nurturing, and captivating settings for elderly individuals.

Usability evaluation and self-acceptance of gerontech

In the context of integrating gerontechnologies into eldercare, it is essential to understand the practical usability and the nuanced self-perceptions and acceptance of older people regarding these advancing technologies. This section explores the dual facets of usability evaluation and self-acceptance. It recognizes that the efficacy of gerontechnologies relies not only on their functionality but also on their alignment with the distinct needs and viewpoints of older adults. A detailed examination of user experience and acceptability levels, incorporating specific research characteristics such as sample sizes, demographic details, and reported statistical trends, provides deeper insights into the effectiveness and reception of the technology.

This analysis includes quantitative metrics and qualitative observations that reveal patterns and variations in user feedback and acceptance. It is worth noting that several studies have shown that older adults can benefit more from gerontechnologies and other assistive technologies compared to regular care or traditional therapy (Odabasi et al., 2022). This suggests that there is hope for meeting the care needs of older adults and overcoming the difficulties associated with aging. These notable effects encompass diverse aspects, such as improvement in the quality of life (Fritz et al., 2022; Aggar et al., 2023), the restoration of bodily functions and rehabilitation in older adults (Dalla Via et al., 2022). The reviewed articles have also demonstrated that certain researchers aimed to assess the influence of a gentle bedside communication robot (Obayashi et al., 2022). The results emphasized the efficacy of communicative robots in lessening psychosocial distress, while also acknowledging the positive interaction facilitated by non-verbal plush toys (Fritz et al., 2022). The researchers also assessed a different set of emerging technologies that functioned as a source of emotional assistance (Chen et al., 2022) for older adults. These technologies resulted in positive experiences and improvements in mood, involving increased laughter, more positive facial expressions, reduced psychological distress, reduced anxiety and depression, decreased loneliness, heightened feelings of interest and satisfaction, and enhanced mental wellness (Papadopoulos et al., 2022), alternatively, as a facilitator of social connections between older adults and their families or healthcare professionals, which resulted in notable enhancements in older adults' communication and interaction abilities, as evidenced by increased verbal communication and visual contact (Blindheim et al., 2023).

Transitioning from the usability evaluation, it is crucial to examine the complex connection between self-perception and the acceptance of gerontechnologies. Comprehending how older people perceive and engage with these technologies is crucial for enhancing their overall usability and efficacy. The analyzed publications offer insight into the diverse perspectives of elders regarding the adoption of gerontechnologies. The inquiry into the experiences of senior citizens with assistive technologies, including Bomy (Gaststeiger et al., 2022), a robot that offers daily care, and the 'smart cane' (Bluethmann et al., 2023) intended to aid older cancer survivors with mobility, underscores the importance of user-centered design that prioritizes the needs and preferences of the individual. The adoption of smart homes for older individuals has prompted significant ethical questions, emphasizing the necessity of balancing technological progress with ethical ramifications (Pirzada et al., 2022). Other investigations have elucidated the importance of control in elder care technology and provided useful insights into design concepts that might enhance user happiness and acceptance from the standpoint of seniors (Berridge, 2022). Moreover, the experiences of senior individuals with voice-activated technologies, such as Alexa, and the significant relationships formed with robotic companions, like Paro, offer insights into the emotional and psychological aspects of engaging with these gerontechnologies. The study in (Kabacińska et al., 2023) investigates the effect of environmental awareness on customers' propensity to adopt smart home devices. The results indicate that many contextual factors, including cultural attitudes, environmental conditions, and individual user requirements, substantially influence the reception of these advances. The phrase 'substantial influence' denotes the quantifiable and significant impacts that these aspects exert on users' readiness to accept and proficiently utilize the technologies. The article presents comprehensive information on these aspects, incorporating particular examples and quantitative data that demonstrate their influence on user approval. The analysis of elderly home care recipients' experiences with digitalization, particularly the use of robots for medication management, improves understanding of the challenges and opportunities in integrating technology into the health and care sectors. Moreover, some researchers examined the variables that influence customers' incli-

nation to purchase smart home security systems based on a behavioral study of elderly people (Philip, et al., 2023), as well as users' intentions to secure IoT smart home networks, emphasize the interdependence of security, technology, and user approval. The utilization of machine learning methods to analyze social data for comprehending consumer behavior highlights how elders' perceptions of security risk affect their decisions to buy smart home devices. (Nilashi et al., 2022). The examined publications clarify various complex facets of older individuals' perceptions and acceptance of gerontechnologies. These elements include user experiences, which entail usability and accessibility issues; ethical dilemmas concerning privacy and autonomy; emotional connections, particularly the influence of technology on users' identity and independence; and contextual factors like cultural norms and living conditions. Each of these aspects contributes to the complexity of the research landscape by affecting technology adoption in subtle ways. The studies indicate that resolving these issues may necessitate focused interventions, like enhancing design for usability, formulating comprehensive ethical principles, and customizing solutions to particular cultural and environmental situations.

Implementation hurdles of gerontechnologies

Notwithstanding the previously articulated hopeful perspective, a thorough examination of the compiled data uncovers other intricate challenges to the deployment of gerontechnologies. These complications emerge from hurdles like technology integration with current systems, diversity in user requirements and preferences, legal and ethical concerns, and obstacles pertaining to cost and accessibility. Each element complicates the successful deployment of these technologies, necessitating comprehensive solutions to tackle the diverse and interconnected challenges mentioned. A consistent theme emerges in the reviewed articles concerning the challenges associated with the use of various assistive technologies. The primary obstacles that are particularly prominent are the ethical concerns surrounding the use of care robots in elder care facilities (Hung, et al., 2022, Wang, et al., 2023), since it highlights the twofold possibilities and difficulties of incorporating robotics in long-term care facilities (Johanson-Pajala, et al., 2022), emphasizing the significance of addressing technological hazards and ethical considerations. The increasing interest in robotics for long-term care necessitates a careful and ethical decision-making process that involves all relevant parties, evaluates the advantages and disadvantages, minimizes potential harm, respects individual freedom, takes into account cultural sensitivity and fairness, and safeguards privacy in routine care procedures. Similarly, some researchers have also examined the difficulties related to implementing care robots in elder care facilities, with the goal of meeting the needs of the aging population and decreasing dependence on professional caregivers. The findings indicate difficulties that exist at both the individual and systemic levels, which include attitudes towards technology, ethical concerns, cooperation, and the requirement for knowledge and expertise (Johnston, 2022) and it also highlights challenges such as privacy, data security, and the possibility of unforeseen repercussions arising from the usage of this type of gerontechnologies in elder-care. The ethical aspects underscore the need for a deliberate and thorough approach to the creation and implementation of gerontechnological solutions, underlining the significance of maintaining ethical principles in technological advancement (Wang, et al., 2023). Moreover, the effective deployment of gerontechnological interventions is significantly influenced by the emergence of digital literacy among seniors (Geerts et al., 2023). Research continually emphasizes the necessity of specific treatments to improve digital literacy, closing the divide and guaranteeing that older folks can effectively utilize the advantages of these technologies.

Another key challenge is the financial viability (Hof & Pottharst, 2023) of the assistive technologies and the economic factors involved in implementing these technologies in long-term care facilities focusing on concerns regarding expenses associated with its implementation, as well as for elderly individuals with restricted financial means (Hof & Pottharst, 2023).

Consequently, it is essential to emphasize financial considerations to surmount implementation challenges and facilitate the efficient integration of gerontechnologies in various hospital and caregiving settings (Genge et al., 2023). The examined publications have highlighted that numerous gerontechnological advancements remain in the developmental phase, presenting a considerable difficulty. Some technologies remain in nascent phases of development and lack the requisite refinement for seamless integration into the caregiving landscape and the dynamic nature of seniors' daily activities. The immaturity in this regard may impede the broad acceptability and efficacy of these technologies in tackling the complex difficulties related to aging. The hurdles encompass varied individual requirements, fluctuations in health situations, integration with current care systems, and the demand for tailored solutions, all of which augment the total complexity of properly adopting and employing gerontechnologies. (Sabagh, et

al., 2023). Moreover, certain innovations are especially designed for basic tasks, thereby limiting their flexibility and appropriateness for the diverse needs of older adults (Luo et al., 2023). Furthermore, the assessment of specific gerontechnologies is primarily confined to controlled laboratory settings, leading to a discrepancy between theoretical promise and practical effectiveness in real-world scenarios (Tobis, 2023). To facilitate the progression of these new solutions, it is imperative to rectify the deficiencies in maturity, functionality, and empirical testing. This will allow these solutions to progress beyond the theoretical phase and effectively address the intricate and dynamic issues encountered by older folks in their daily lives.

Discussion

The main goal in conducting this systematic literature review was to identify the most reliable sources of information regarding the creation and application of technological solutions for the care of the elderly. This article discusses the changing landscape of technology that has the potential to alter the care that older people receive and address the research objective of identifying the current trends in gerontechnology research in the care field. We conducted a thorough analysis of publications focusing on new developments in the field of gerontechnologies for elderly care. In addition, we broadened our investigation by inquiring about the level of usability of these assistive technologies in the field of care and the degree to which older adults embrace them. Finally, we examined the challenges and obstacles that may impede the intended use of these technologies during their implementation. Furthermore, we have expanded the analysis to understand the obstacles that may arise during its implementation.

Post-pandemic, gerontechnologies have evolved to address not just physical safety but also social, emotional, and cognitive needs. In the pre-pandemic phase, the focus was mainly on assistive devices with an emphasis on devices like mobility aids, often neglecting social well-being (Brims et al., 2019; Stavropoulos et al., 2020). The pandemic accelerated the adoption of more advanced, user-independent technologies, leading to the integration of mature systems like remote monitoring and fall detection. Additionally, care and social robots, ambient living devices, and Artifcial Intelligence (AI) driven personalized care emerged to combat isolation and mental health challenges. This shift reflects a broader, more holistic approach to eldercare, combining health monitoring with emotional and social support.

The analysis has also indicated that several studies utilized different technical solutions designed for certain older populations. Certain researchers concentrated on developing ambient assistive living technology to promote independent living for elderly adults staying alone in their homes. In contrast, other researchers focused on developing novel solutions specifically for elderly folks living in nursing homes, with the objective of reducing the burden on care workers and offering unique experiences for seniors. The discussion on recent developments in gerontechnology reveals both intriguing opportunities and considerable challenges in elderlycare. These technologies offer the promise of enhanced autonomy, increased security, and tailored care solutions specifically developed for the unique needs of elderly adults (Fasoli et al., 2023). Advanced health-monitoring systems, fall detection, and ambient assisted living technology can significantly improve the quality of life for older individuals by meeting various health and caregiving needs (Nguyen, 2023). Nevertheless, as the domain of gerontechnology progresses, it encounters noteworthy obstacles that necessitate meticulous deliberation.

Although there are many new advancements in gerontechnology, it is important to highlight that there has been limited focus on thorough discussions regarding the practical ways to address the hurdles of its implementation in the care field. Prior research in the field has primarily concentrated on developing novel technologies, highlighting their capabilities and functionalities. However, there is a significant deficiency in tackling the practical obstacles that hinder the smooth incorporation of these advancements into the everyday routines of elderly individuals aging in a home or care facilities. Identifying and tackling these difficulties are crucial for guaranteeing the effective implementation and long-term effectiveness of gerontechnological solutions. It is crucial for the field to mature and provide tangible benefits to the aging population by not only creating new technologies but also developing effective strategies to tackle current problems.

Future studies should emphasize a holistic strategy that integrates technological breakthroughs with pragmatic solutions to enhance the efficacy and acceptance of gerontechnological innovations in elder care. This review highlights the dual nature of gerontechnologies in caregiving, recognizing their potential to enhance the quality of life for the elderly while also addressing the intricate factors necessary for their ethical and effective incorporation into the care ecosystem for older adults.

Future research

Future research in the domain of gerontechnologies within the caregiving sector has numerous avenues for exploration. Given the complexity and interdisciplinary nature of this domain, it is essential to adopt more stringent and uniform methodologies in research to provide a more effective comparison and synthesis of results. Subsequent research may emphasize the establishment of universally acknowledged criteria and outcome assessments to gauge the effectiveness and impact of gerontechnologies in caregiving. Further work should concentrate on assessing the scalability and feasibility of integrating gerontechnologies into diverse care settings, including home-based care and long-term care facilities by evaluating both the technical performance and the cost-effectiveness, as well as the logistical obstacles of adopting these technologies in various locations in order to ensure their sustainability and practical use.

Moreover, ethical concerns remain a central area for future research. It is advisable that the forthcoming research emphasizes enhancing understanding of user perspectives, particularly regarding how elderly individuals perceive the integration of gerontechnologies into their care routines. Privacy problems, and the ethical implications linked to the incorporation of contemporary technology in the care of older individuals, including the potential for technological dependence on caregivers, need to be explored further.

A substantial gap pertains to the digital competencies of elderly folks. Research should investigate methods to enhance digital literacy in older persons through education and training programs customized to their requirements and capacities. These initiatives should encompass both technical instruction and the creation of intuitive interfaces that necessitate minimal prior knowledge for operation. Moreover, research might investigate the role of caregivers in fostering digital proficiency and the methods by which they can be educated to aid senior individuals in utilizing modern technologies.

Given the developmental phase of many gerontechnologies, many of them remain in early stages of development and lack the refinement necessary for smooth integration into the caregiving landscape. Future research should focus on the barriers to adoption for these nascent technologies, including user acceptability, and real-world functionality.

Ultimately, due to the interdisciplinary character of gerontechnology, it will be essential to promote cooperative research endeavors among gerontologists, technology professionals, ethicists, and care providers. This is necessary in order to provide broad solutions that effectively address the distinct requirements of an elderly population.

From a technological standpoint, the future developed gerontechnologies should emphasize the implementation of universal design principles to guarantee that technologies are accessible, usable, and easily navigable for seniors. This entails developing user-friendly interfaces that cater to cognitive and physical differences, including voice-activated devices, direct visual assistance, and adaptive designs customized to individual capabilities. Technologies must emphasize straightforward controls that are simple to learn and operate, to enable seniors, irrespective of their physical or cognitive condition, to interact with them pleasantly. Furthermore, these technologies must be multilingual and adaptive to various cultural contexts, considering linguistic variations, societal conventions, and differing healthcare systems across the globe.

The incorporation of Artificial Intelligence (AI) must be executed transparently, elucidatively, and in accordance with ethical standards, especially in healthcare decision-making. Transparent communication about personal data usage is essential for fostering trust and safeguarding privacy. Developers and engineers must ensure that AI systems are built to be egalitarian, precise, and devoid of bias, in order to guarantee fair treatment for all users. Moreover, data security and user consent must be prioritized in the development process to protect personal information and enhance transparency.

Limitations

Although this systematic review aims to provide a comprehensive analysis of gerontechnologies in the field of care, it is important to acknowledge certain limitations. The presence of diverse study designs, techniques, and outcome measures across the included studies may provide difficulties in synthesizing and comparing the results. Additionally, the omission of grey literature and non-peer-reviewed sources could add a possible bias, as novel interventions and developing trends are occasionally initially published through non-traditional scientific platforms. The emphasis on English-speaking publications may result in linguistic prejudice, thus restricting the inclusiveness of varied perspectives and discoveries from non-English sources. Furthermore, the dynamic and fast-paced advancements in gerontechnologies present a barrier, as any progress made beyond the review period may not be

comprehensively documented. Regardless of the presence of constraints, the synthesis of current evidence provides useful insights into the current state of gerontechnologies in the care domain and sets the foundation for future research and developments in this rapidly evolving sector.

Conclusion

This systematic literature review provides a thorough examination of the gerontechnology ecosystem within the context of elder care, focusing on the period from 2022 to 2023. The analysis reveals that gerontechnologies have made notable strides in enhancing the quality of life for older adults.

These innovations have shown considerable advantages in enhancing well-being, broadening the accessibility of care services, and elevating patient happiness. Technological innovations have the capacity to transform aged care by providing solutions that cater to the diverse needs of older adults, ranging from everyday support to health monitoring. Notwithstanding these developments, the analysis reveals numerous intricate hurdles that hinder the widespread acceptance and efficacy of gerontechnologies. Principal impediments consist of:

Digital literacy: Numerous older people encounter challenges in utilizing advanced technologies owing to differing levels of digital literacy. This obstacle can restrict the functionality and efficacy of gerontechnological solutions.

Equitable access: Disparities in technological access, influenced by socioeconomic variables and physical location, result in disparities in who can benefit from these breakthroughs.

Ethical considerations: Matters pertaining to data privacy, consent, and the potential for technology to encroach upon personal autonomy pose substantial ethical dilemmas.

The intricacies require a thorough and planned methodology to guarantee that the implementation of gerontechnologies is both efficient and mindful of the varied demands of the aging demographic. Confronting these difficulties necessitates the formulation of specific solutions, such as enhanced digital literacy initiatives, legislation to promote fair access, and comprehensive ethical guidelines.

In order to align with the study objectives established at the outset of this evaluation, this review has methodically examined contemporary trends in gerontechnology, emphasizing significant domains of invention and application.

In addition, it examined the determinants affecting the usability and acceptance of these technologies, offering insights into user experiences and obstacles.

The review has also identified and examined the principal problems related to the implementation of gerontechnological solutions, providing a detailed comprehension of the concerns involved.

The insights derived from this review are beneficial for various stakeholders, including policymakers, healthcare professionals, and researchers. They establish a basis for developing strategies that enhance the benefits of gerontechnologies while mitigating potential disadvantages. By utilizing these insights, stakeholders can formulate more effective, equitable, and ethical strategies for enhancing elder care, ensuring that technological advancements correspond with the objective of delivering comprehensive, personalized care for older adults.

The research highlights the necessity of overcoming implementation challenges to optimize the advantages of gerontechnologies. It offers critical insights by delineating measures to improve technological acceptability. This thorough comprehension establishes a basis for formulating effective, empathetic, and user-focused strategies to enhance elder care via gerontechnology.

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