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Challenges and Ethical Considerations in Implementing Assistive Technologies in Healthcare

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Abstract: Assistive technologies are becoming an increasingly important aspect of healthcare, particularly for people with physical or cognitive problems. While earlier research has investigated the ethical, legal, and societal implications of AI and assistive technologies, many studies have failed to address real-world obstacles such as data privacy, algorithm bias, and regulatory issues. To further understand these issues, we conducted a thorough analysis of the current literature and analyzed real-world case studies. As AI-powered solutions become more widely used, we discovered that stronger legal frameworks and robust data security standards are required. Furthermore, privacy-preserving procedures and transparent accountability are critical for retaining patient trust and guaranteeing the effective use of these technologies in healthcare. This research provides important insights into the ethical and practical challenges that must be tackled for the successful integration of assistive technologies.

Keywords: assistive technology; AI in healthcare; patient data privacy; patient data security

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1. Introduction

Over the past few years, assistive technologies have played a crucial role in healthcare, particularly in addressing the needs of individuals with physical disabilities or cognitive deficits. The implementation of these technologies presents various challenges and ethical considerations that need to be carefully navigated. One key consideration is the ethical, legal, and social implications of using artificial intelligence systems in healthcare. In [1], the importance of a proactive approach by government, regulators, and professional groups is emphasized, to ensure the introduction of artificial intelligence (AI) in robust research contexts and the development of a sound evidence base regarding real-world effectiveness. Furthermore, ref. [2] highlighted the interdisciplinary nature of incorporating legal, ethical, medical, and information and communication technology aspects in the discussion of big data and patient data ownership in healthcare. The authors stressed the need for a sophisticated analysis of the issue, particularly in addressing ethical challenges related to the use of patient data for medical research.

In the context of assistive technologies, Ref. [3] discussed the intertwining relationship between regulation, design, and human needs in the development of care technology such as lower limb exoskeletons. The authors raised concerns related to cognitive safety, prospective liability, and privacy that need to be addressed in the implementation of these technologies. Another study [4], focused on the emerging issues of intelligent assistive technology use among people with dementia and their caregivers in the United States. It highlighted challenges related to socioeconomic status, technological literacy, and ethical and legal implications that should be considered in the design and development of assistive technologies for older adults with cognitive deficits. Moreover, an optimized tongue drive system for disabled persons that utilizes artificial intelligence to enable users to communicate with their surrounding environments was presented in [5]. Ref. [6] discussed the implementation of assistive technologies and robotics in long-term care facilities, with a specific focus on the emotions of employees and leaders within these institutions.

Hospitals face challenges when integrating assistive technologies, including concerns about patient privacy, data security, and ethical considerations [7–10]. These challenges stem from the need to safeguard sensitive patient information, comply with regulations including the HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General Data Protection Regulation), and mitigate the risk of data breaches. Issues such as algorithmic bias, fairness, and interpretability also arise with the use of artificial intelligence and machine learning in healthcare settings. To address these challenges, hospitals must implement robust data security measures such as encryption, anonymization, and access controls, while prioritizing transparency and accountability in AI-driven decision-making processes. Emerging trends in privacy-preserving techniques, such as federated learning and differential privacy, offer promising solutions for balancing innovation with patient rights and regulatory requirements. Additionally, understanding which information should be shared with external entities and when to share it is crucial to ensure the well-being of patients in technology-rich environments [11–13].

2. Objective

The objective of this research was to identify and analyze the challenges healthcare professionals encounter when integrating assistive technologies, including issues related to patient privacy, data security, and ethical considerations. Also, the authors attempted to explore proposed or implemented solutions to address these challenges. While there are relevant research articles published in the field (i.e., AT for Alzheimer's disease), there are no literature reviews available describing different types of assistive technologies used in various healthcare fields. Many of the existing studies have not addressed practical challenges, such as algorithm bias, data privacy, and regulatory concerns. In order to better understand these challenges, this study thoroughly reviews the existing literature and examines real-world case studies.

The research questions were formulated as follows:

- What are the most popular assistive technology methods used in hospitals and other healthcare settings for patient profiling and treatment?
- What are the challenges faced by healthcare professionals in implementing assistive technologies for patient profiling and treatment, and what ethical considerations surround the use of such technologies in healthcare settings?
- How does the introduction of care robots and socially assistive technologies affect the workload and job satisfaction of healthcare professionals?
- What factors influence the successful adoption and long-term use of assistive technology in community health settings, and what are the barriers to widespread implementation?

3. Methodology

The five essential steps that [14] identified as necessary for conducting systematic reviews served as the foundation for this study's methodology. Formulating the research questions—which are listed above—was the first step. The second step was to search for eligible research papers in electronic scientific databases, including PubMed, Google

Scholar, Scopus, and Science Direct, within the years 2018–2024. The same search queries were performed for all of the databases listed above.

The authors utilized specific keywords in the search strings, such as "assistive technology", "smart watches", "health monitoring devices", "hospitals", "patient profiling", and "treatment", to ensure relevance to the research questions. These keywords were used with the addition of "AND" and "OR" between them, in order to combine them properly. The search strings used by the authors are presented below (see Table 1).

Table 1. Search strings used by the authors.

General Search Strings	("Assistive technologies" AND "Hospital" AND "Effectiveness")
For Patient Profiling	("Assistive technologies" AND "Hospital" AND "Patient profiling") OR ("Assistive technologies" AND "Hospital" AND "Diagnostic tools") OR ("Assistive technologies" AND "Hospital" AND "Patient monitoring systems")
For Treatment	("Assistive technologies" AND "Hospital" AND "Treatment") OR ("Assistive technologies" AND "Hospital" AND "Rehabilitation devices") OR ("Assistive technologies" AND "Hospital" AND "Robotic surgery") OR ("Assistive technologies" AND "Hospital" AND "Therapeutic devices")
For Outcome and Impact	("Assistive technologies" AND "Hospital" AND "Patient outcomes") OR ("Assistive technologies" AND "Hospital" AND "Clinical outcomes") OR ("Assistive technologies" AND "Hospital" AND "Healthcare efficiency") OR ("Assistive technologies" AND "Hospital" AND "Clinical workflow") OR ("Assistive technologies" AND "Hospital" AND "Treatment efficacy") OR ("Assistive technologies" AND "Hospital" AND "Patient care")

The third step was developing the eligibility criteria to evaluate the research papers' suitability for this review. First, all articles should be published in English, to ensure accessibility and understanding for a broader audience. Second, the authors opted to include articles published within a specific timeframe between 2018–2024 to focus on recent developments and trends in the field. Regarding the studies' content, direct relevance to assistive technology was considered a criterion. Studies that explicitly address assistive technologies, such as smart watches, health monitoring devices, robotics, and related technologies in healthcare settings, were included. The main targets were the use of assistive technologies in hospitals, patient profiling, and treatment, rather than publications that primarily discuss general technology use or non-healthcare contexts. Primary research articles and conference papers that also involved primary research were selected. The number of studies that were initially identified in the databases was 634. After the removal of duplicates and the screening of the articles according to the defined eligibility criteria, the authors selected 29 articles for analysis in this review.

The fourth step involved summarizing the evidence presented in the final set of selected studies. The evidence was categorized according to the main research questions that had previously been formulated. More specifically, in the Section 4, the authors present the results of analysis of the aspects of specific popular assistive technology means in healthcare settings, the challenges in implementing assistive technologies by healthcare professionals, some important ethical considerations, effects on workload and job satisfaction, and the main barriers and facilitators of their implementation. The fifth and final step of the review involved interpreting the findings, which is presented in the Section 5. The findings in each category were analyzed in relation to the original research questions of the review.

We made use of PRISMA Flowchart (see Figure 1).

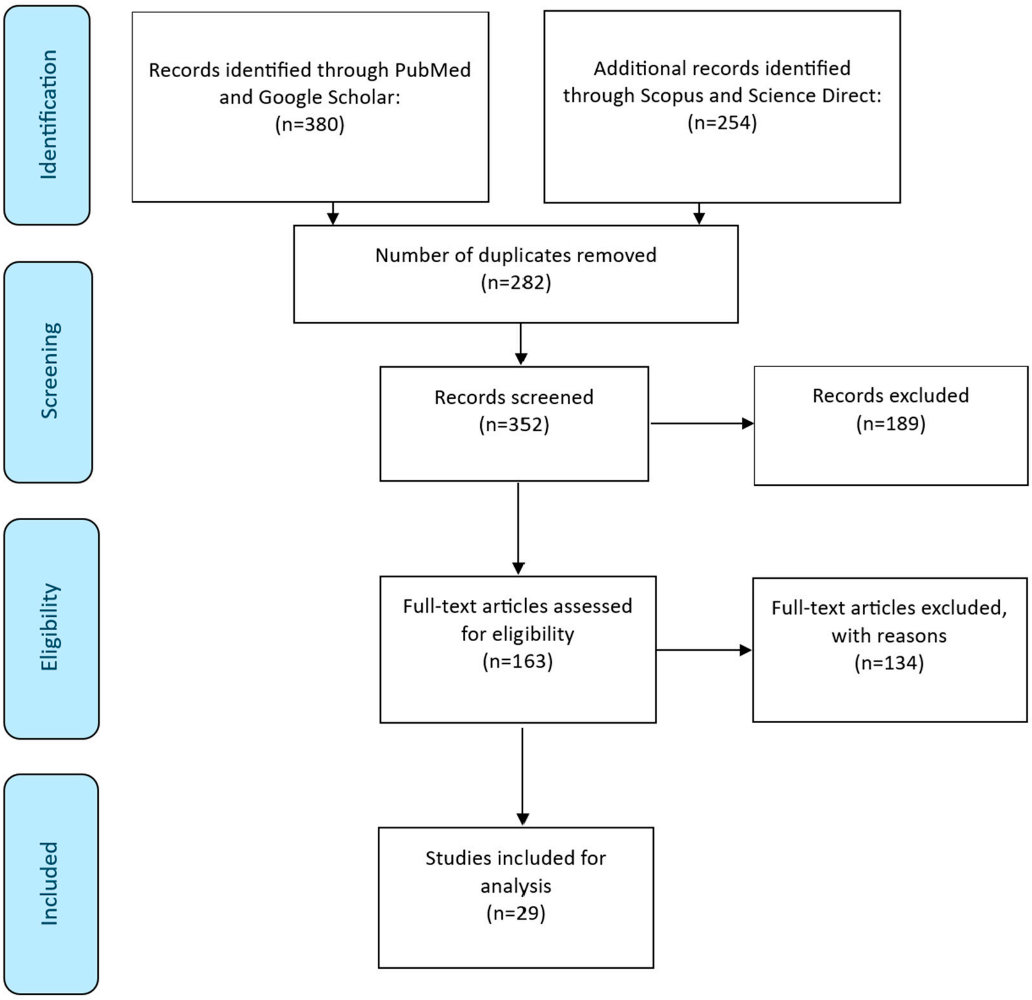

Figure 1. Selection of the analyzed research papers based on PRISMA flowchart.

4. Results

4.1. Popular Assistive Technology Methods in Healthcare Settings

Most of the eligible studies that were included in this review implemented robots as their main assistive technology methods. Specifically, 15 out of 29 studies utilized robotic technology in various forms, including some very popular platforms. There were also studies in which the researchers conducted survey-based assessments about robotic technology in general. The development, testing, and application of social robots in healthcare environments is constantly growing. However, the introduction of robotics in healthcare is not new: the first robot-assisted surgical procedure took place in 1985 and since then, technology has advanced significantly, which has improved robot capabilities [15].

The Adaptive Robotic Nursing Assistant (ARNA) is a service robot designed to assist nurses in tasks such as helping patients walk and sit in hospital environments. ARNA features an omnidirectional mobile base and a seven-degree-of-freedom robotic arm, allowing it to navigate unstructured environments and assist with physical tasks. It includes advanced control systems, such as a neuroadaptive controller, to facilitate physical human–

robot interaction (pHRI) and adjust to different user needs. ARNA can perform tasks like fetching and transporting objects, providing ambulatory support, and monitoring bedridden patients. Its usability was tested with nursing students, showing promising results in terms of ease of use and usefulness, indicating its potential for frequent use in healthcare [16].

"Pepper" was used in two out of twenty nine studies included for analysis in this review. Pepper is a humanoid robot designed for social interaction, which has been commonly used in healthcare and elderly care settings. It can communicate through voice, gestures, and visual displays. It is equipped with 2D (two-dimensional) and 3D (three-dimensional) cameras, microphones, and a touchscreen, and is around 1.2 m high. Its primary functions include offering social engagement, physical and cognitive activities, and acting as a companion. Pepper has been deployed in various settings, such as care homes, to motivate elderly patients through exercises and interactive games. However, it often requires human moderation, similarly to many other robotic platforms, due to limitations in speech recognition and autonomous movement. Despite these limitations, studies have shown that Pepper can positively impact patient engagement and social interaction in certain settings [17,18].

The "PHAROS" (PHysical Assistant RObot System) and "PHAROS 2.0" (PHysical Assistant RObot System Improved) were used in two studies [19,20]. The first PHAROS system, introduced in 2018, is a robotic platform designed to assist elderly individuals with their physical activities at home. It utilizes a Pepper robot to interact with users, recommending personalized physical exercises based on their health status. The system employs a combination of human exercise recognition, powered by deep learning, to monitor and classify physical activities in real-time, adjusting exercise suggestions as needed. This adaptive approach promotes healthy living and active aging by continuously updating the exercise regimen, based on the user's performance and health evolution. The PHAROS 2.0, introduced in 2019, is an improved version of the original system. It enhances motion capture capabilities by indicating the degree of completeness of each exercise and identifying areas where users struggle. Then, it provides real-time feedback to help users correct their performance. The recommender system is also upgraded to record the temporal evolution of the user's health, their preferences, and their previous performance. Additionally, PHAROS 2.0 recommends batches of exercises rather than single activities, offering a more comprehensive and personalized experience.

"Zora" is a humanoid robot designed for social interaction and rehabilitation, especially for older individuals in nursing homes. Zora was developed by Softbank Robotics and was equipped with software created by a company named Zorabots. This humanoid robot can be used to facilitate physical and entertainment activities and support rehabilitation. It is 57 cm in height and it can walk, dance, talk, and engage in a variety of social interaction activities. In some studies, Zora was found to have a positive impact in promoting movement and positive affect in group activities, both for elderly clients and staff. In the two-year evaluation study that was included for analysis in this review, Zora was found to have a positive impact on both the elderly clients and the nursing homes' staff, promoting movement and positive affect in group activities. It is of note that 14 nursing homes in the Netherlands participated in this research. Some barriers were identified in the implementation process, namely software malfunctions, long start-up times, and communication issues. However, the study identified the potential of Zora to improve the quality of care services in psychogeriatric wards, where elderly individuals responded well in organized activities and one-on-one interactions [17].

A humanoid care robot called "Silbot" has been used in Korea for cognitive training activities, especially catering to the needs of the elderly. This robot has various motor capabilities, as it can move its arms and dance, and also display facial expressions and engage users in games designed to improve their cognitive and social skills. Silbot was implemented before the COVID-19 pandemic and became even more relevant during the pandemic as a non-contact tool for promoting interaction. Although Silbot enhances engagement and class interest, its operation relies on human input, as an operator must lead the programs. Silbot has played an important role in supporting cognitive training and social well-being in group settings, despite some technical limitations, i.e., poor voice recognition and the need for frequent recharging. The "Hyodol" robot, which was used in the same study, is a doll-shaped care robot developed for the elderly, especially those living alone or with dementia. Hyodol can communicate in Korean when stroked on the head or back, providing verbal output by using familiar words like "grandma" or "grandpa". It is effective in providing emotional support, thus alleviating feelings of loneliness and depression that were more evident throughout the COVID-19 pandemic. The robot's tactile capabilities allow users to engage with it in various ways, such as holding it. Hyodol can also offer practical and emotional support through providing reminders for tasks, such as taking medication, to users [21].

The "Matilda" robot is a socially assistive robot designed for emotional interaction purposes, particularly for older individuals. This robot was developed by NEC Japan in collaboration with La Trobe University. Matilda has equipment that allows social engagement among older adults. Additionally, the robot has a baby-like face and can perform various interactive activities, such as singing, dancing and playing popular games (e.g., bingo). According to research, Matilda has helped carers by implementing certain tasks like pronouncing bingo numbers, allowing the carers to focus on monitoring and interacting with the elderly. Carers reported that the robot enhanced their ability to engage with the elderly. Additionally, according to them, it managed to alleviate some of their workload [22].

The "Huggable" social robot is a teddy bear shaped robot with the aim of meeting the emotional needs of hospitalized children. The Huggable robot was created as a collaboration between Boston Children's Hospital, the Massachusetts Institute of Technology (MIT) Media Lab, and Northeastern University to help reduce stress, pain and feelings of isolation in young patients. The Huggable robot was first tele-operated by a human through "Wizard of Oz" methodology in trials, and engaged children in activities such as conversation, games and songs, to enhance their hospital experience. The study used for review included children interacting with the Huggable robot, who were more positive than those that interacted with a non-robotic plush bear or a tablet version of the bear. This means that the physical presence of a robot typically works better to keep children emotionally engaged. There is preliminary evidence suggesting that the Huggable robot could help make emotional and some physical connections, while offering comfort to hospitalized children and reducing the need for medication and possibly helping to improve recovery outcomes [23].

The aim of the "AMiCUS 2.0" (Adaptive Head Motion Control for User-friendly Support 2.0) system is to provide support, via an advanced assistive technology system that allows tetraplegic individuals, and specifically those with multiple sclerosis (MS), to regain some autonomy through the use of the control of a robotic arm and through the use of head movements alone. In contrast to "AMiCUS 1.0", this system eliminates the need for head gestures, and is more ergonomic, easier to use, and more accessible to people with severe physical limitations. In real time, AMiCUS 2.0 translates the user's movements into commands for operating the robotic arm, using motion sensors placed on the user's head. The design is intuitive, so that even a person with a very limited head ROM (range of motion) can still use the system. Other improvements included in AMiCUS 2.0

involve improved accessibility and usability. Focused on adaptability independent of skill level, the learning has been designed for beginners who may find more complex controls difficult. Users are able to switch between control modes smoothly and receive large, high contrast, visual feedback for those with visual impairments. Enabling users to perform tasks independently, such as grasping and manipulating objects, shows its potential to also improve the quality of life of users with advanced MS, while also extending their autonomy [24].

The "Mini" robot has been developed as a social robot that will help the elderly in adjusting to their daily lives, both in their homes and in nursing facilities. Mini has been designed to provide seniors with services in a variety of fields, including safety, entertainment, personal attendance, and cognitive stimulation. Researchers designed it as a desktop robot with expressive capabilities such as verbal communication, tactile sensors, and visual displays, to allow human–robot interaction. Besides being equipped with cameras and microphones, enabling monitoring of users, Mini has features that enable it to offer personalized services to users, such as reminders and entertainment. The user-centered design that Mini benefits from includes expertise in the fields of cognitive psychology, geriatrics, and robotics as input. The robot also has a cartoon-like figure that makes it more friendly and approachable, in order to permit elderly users to accept it more easily. Mini aims to enhance the quality of lives of seniors through cognitive exercises and games. Although this research needs to be extended to improve the role of the robot in motivating users to be more autonomous, preliminary studies showed that users found the robot helpful and user-friendly [25].

"RoboTSS" (Robotics for Team Support System) is a robot-centric team support system for the support of healthcare teams, especially nurses, in safety-critical environments such as hospitals. RoboTSS was developed through a collaborative process with nurses from multiple hospitals and features group detection, tracking, and motion forecasting, allowing for real-time engagement with teams. The system empowers nurses to prevent medical errors by assisting with resuscitation procedures, improving team spatial coordination, and managing supplies. It also aims to disrupt hierarchical power dynamics in healthcare settings, where nurses often struggle to challenge unsafe physician practices. RoboTSS can enforce safety protocols, reduce nurse workload, and ensure real-time error identification by serving as a neutral party, thus promoting a safer and more efficient patient care environment [26].

Some of the studies included in this review implemented assistive technology methods other than robotics. Ref. [27] utilized "Point-of-Care Ultrasound" (POCUS), which is a portable and highly accessible diagnostic tool used by clinicians at the patient's side, providing real-time imaging to assist with decision-making. In community and prehospital settings, POCUS is most useful for early diagnosis, improvement of patient outcomes, and directing treatment. It is portable and its image quality is being improved, expanding its application in several healthcare settings. POCUS is seen by some practitioners as a potential tool that will facilitate better care for patients, helping with referrals to specialists and earlier detection of serious conditions. However, there are challenges around wider adoption, as it requires more training, better governance, and quality assurance. Additionally, POCUS implementation in community settings necessitates investment in equipment, education, and support systems in order to use it effectively and achieve better patient outcomes.

The smart speaker "Alexa Echo Show 8" is a voice-activated smart speaker device that includes a screen and helps users in performing daily tasks and communication, as well as to manage their health. In healthcare contexts, the device has been particularly useful to patients, enabling them to manage long-term conditions, such as diabetes and dementia. It can remind users about medication and appointments, it helps them stay organized with daily living activities, and it includes features like recipe suggestions, music, and exercises. It was found to serve as a tool to alleviate feelings of loneliness and help with users' mental well-being by conversation and interactive features for those living alone. It can also increase patient independence and decrease their need for caregivers, since it is equipped with the ability to assist them via voice control, thus promoting physical as well as emotional health [28].

The "ElderTree" interactive eHealth platform aims to enhance the quality of life, social connections and independence of the elderly. ElderTree was developed through the Center for Health Enhancement Systems Studies at the University of Wisconsin–Madison and provides services such as health tracking, medication reminders, social support, and additional motivational tools. The platform is combined with self-determination theory, where people do well as a result of competence, social connection, and autonomy. ElderTree has been found to improve mental quality of life, social support, and reduce depression symptoms in clinical trials, especially in users with high healthcare needs or chronic conditions. While it did not yield overall benefits for all participants, ElderTree has been helpful for those with more serious health issues [29].

"Aria" is a cylindrical-shaped AI-powered smart speaker used in elderly care to provide services such as playing music, giving information and emergency contact. Importantly, it provides emotional support for older adults, especially during isolation, such as during the COVID-19 pandemic. With voice commands, it gives older adults the chance to communicate with caregivers, receive reminders for dealing with tasks such as taking medication, and feel more socially engaged, but without physical contact. It is an AI-based interactive weekly call service to keep in touch with older adults. It schedules regular wellness calls, allowing caregivers to track how they are doing without leaving their home. Both technologies seek to facilitate well-being and safety of the elderly through reducing loneliness and monitoring that the they are effectively following their health routines [21].

The "Touch Talker" is an assistive technology device designed for visually impaired individuals to help them read text on digital devices by "tracing" the text with their finger. Developed as part of Japan's GEAR 5.0 program, the Touch Talker converts displayed text into audible speech, allowing users to trace over the text with their finger, with the corresponding words being read out loud. This device aims to bridge the digital divide for visually impaired users who may struggle with traditional screen-reading software, providing a more intuitive way to interact with written content without needing Braille. It also allows users to adjust settings including font size, line spacing, reading speed, and language to enhance their reading experience. Evaluation experiments, including both visually impaired individuals and blindfolded technical students, demonstrated the effectiveness of the system in speeding up information retrieval compared to traditional text-to-speech methods [30].

"BrainPort Vision Pro" and "The vOICe" (an experimental system for auditory image representations) are sensory substitution devices designed to assist individuals with visual impairments by converting visual information into other sensory modalities. To do this, BrainPort Vision Pro provides tactile feedback to help individuals understand their surroundings. BrainPort has a small camera attached to sunglasses, which allows it to record visual information, then sends it to a tongue sensor array. Electrical signals are transmitted from the array to the user's tongue and the brain learns to understand these signals as visual patterns. It has been shown to be effective in laboratory settings, but in the real world, users find little functionality and have difficulty using it for long enough. On the other hand, The vOICe transforms visual information into audible signals, so that a user can "listen" to their surroundings. With a camera tracking the coordinates of an image and translating these into soundscapes, different pitches and volumes in each speaker increase and decrease to represent the spatial and visual properties of an object. Users have demonstrated improvements in response to localization and spatial navigation through this auditory system. However, these more capable devices require user training, and they are cognitively demanding, which may explain their limited uptake, even though they show great promise [31].

The "Microsoft Band 2" is a wearable smart watch device capable of collecting various physiological data, which makes it useful both for personal health monitoring and for research. Measurements such as heart rate, skin temperature, and electrodermal activity are key markers of autonomic nervous system activity and are provided through the device. The real-time monitoring of physiological responses of the subjects through these features makes the device suitable for conducting studies of emotion-recognition or analysis of stress. In research contexts, continuous data from participants was gathered using the Microsoft Band 2, which is a technological device that is low-cost and non-invasive, for monitoring health signals while performing daily activities. Despite this device being discontinued, consumer-grade wearables' usefulness can be found in the fact that that they can accurately collect patient data for machine learning models and health diagnostics [32].

Ambient assisted living (AAL) systems are innovative technologies for supporting elderly individuals or people with disabilities with independent living and in their safety and well-being. In day-to-day environments, these systems comprise smart home technologies such as sensors, RFID (radio frequency identification) tags, and communication devices by integrating them to monitor vital parameters, detect falls or emergency situations, and provide memory aides or automated reminders. The objective of AAL systems is to increase the ability of individuals to live in their homes for longer, discharging them from direct human caregiving, through self-reliance and increased safety. However, despite the potential benefits, such as emergency assistance and increased safety, acceptance of AAL systems, particularly in professional care contexts, remains mixed. Concerns about privacy, data security, and feelings of surveillance are frequently cited barriers that affect their broader adoption [33].

All of the result are presented in Table 2.

Table 2. Full results with details.

	Reference	Type of Intervention	Type of Assistive Technology	Setting	Sample	Participants' Age	Diagnosis (For Patients)	Expertise (For Professionals)
1	[16]	Quantitave data and questionnaires	"ARNA" robot	Hospital room simulation suite	24	NA	-	Nursing students
2	[27]	Qualitative interview	Point-of-care ultrasound (POCUS)	Online interview	16	36–65 years	-	Physicians, paramedics, etc.
3	[34]	Survey-based assessment (questionnaires)	Robots	Metropolitan area in the western United States	499	18–44 years 45–64 years 65–98 years (avg. 38.7 years)	-	General population (non-experts)
4	[28]	Surveys and focus group discussions (qualitative data)	"Alexa Echo Show 8" Voice activated device (smart speaker)	Participants' homes (UK)	51 (44 patients and 7 informal carers)	50–90 years	Diabetes (both Type 1 and Type 2), dementia, Parkinson's disease, asthma, Behçet's disease, Cushing's syndrome, phenylketonuria, liver disorders, low mood, depression, anxiety, dyslexia, cognitive impairment, severe visual impairment, chronic knee pain, and trauma	Informal carers
5	[35]	Focus group discussion (qualitative data)	Physically assistive robots	Care homes	7	NA	-	Professional carers for older people in care homes
6	[17]	10-week intervention program	"Pepper" robot	Care home	11 (6 older adult residents and 5 caregivers)	80–94 years	Elderly individuals in need of visual and mobility assistance	Caregivers and former manager
7	[19]	Intervention sessions divided into 100 individual parts (one executed each day)	"PHAROS" (PHysical Assistant RObot System)	Controlled lab environment	7	NA	Elderly individuals in need for physical exercise assistance	-
8	[36]	Mixed-methods approach (qualitative and quantitative data)	Mobility assistive technologies (wheelchairs and components, assistive robotics, human–machine interfaces, smart device applications)	Online survey	161	18–65+ years	-	Providers of mobility-assistive technologies (clinicians, engineers, assistive technology professionals, occupational therapists, physical therapists, nurses, physicians, rehabilitation engineers, and technicians)

Table 2. *Cont.*

	Reference	Type of Intervention	Type of Assistive Technology	Setting	Sample	Participants' Age	Diagnosis (For Patients)	Expertise (For Professionals)
9	[29]	Randomized clinical trial (RCT) (eHealth intervention group and control group)	"ElderTree" eHealth platform (interactive website)	Home-based intervention	390	<65 years	Having at least one health risk factor in the preceding 12 months (including one or more falls Receipt of home health services Skilled nursing facility stay Emergency room visit Hospital admission Sustained sadness or depression)	-
10	[37]	Randomised controlled trial (intervention group and control group)	Assistive technology and telecare (ATT) (safety devices, reminder/prompting devices, monitoring devices, communication devices	Home-based setting (UK)	495	65–80 years 80+ years	Dementia or cognitive difficulties sufficient to suggest dementia, participants with a high risk of safety concerns or with a history of wandering were also included	-
11	[38]	Mixed-method design (qualitative and quantitative data)	"Zora" robot	Nursing care organizations	245 elderly residents 62 professionals	NA (for elderly residents) 16–62 years (for professionals)	Elderly individuals with psychogeriatric problems (e.g., dementia). Some were also in day care or had somatic or psychiatric conditions	Activity counselors, nurses, trainees, policy makers, physiotherapists, and volunteers
12	[21]	Data collected through focus groups and individual interviews (qualitative)	"Silbot" humanoid robot, "Hyodol" doll-shaped care robot for emotional support, "Aria" cylindrical-shaped smart speaker, "Care Call" weekly interactive call service using AI-based technology	Community health centers	18	25–59 years	-	Nurses with work experience in caring for older adults
13	[22]	Mixed-methods design (qualitative and quantitative data)	"Matilda" robot	Residential aged care facilities	Qualitative study (Study 1): observations of 13 carers, 15 in-depth interviews, and 3 focus groups with carers. Quantitative study (Study 2): 302 carers	Qualitative study: 35–60 years Quantitative study: 20–60 years	-	Carers with varying levels of experience in aged care

Table 2. *Cont.*

	Reference	Type of Intervention	Type of Assistive Technology	Setting	Sample	Participants' Age	Diagnosis (For Patients)	Expertise (For Professionals)
14	[39]	Mixed-methods approach (qualitative and quantitative data)	Various digital technologies	Online survey	578	18–74 years	-	Diverse group of participants (non-experts)
15	[30]	Quantitative approach	"Touch Talker" digital text-to-speech system	Controlled environment	12 (6 visually impaired individuals and 6 blindfolded individuals with normal vision)	21–38 years (for visually impaired individuals) 15–20 years (for blindfolded individuals with normal vision)	Varying degrees of visual impairment	-
16	[31]	Quantitative approach	High-tech assistive technologies designed for people with visual impairments (e.g., "BrainPort Vision Pro", "The vOICe")	Online survey	25	21–68 years	Individuals with visual impairments	-
17	[23]	Quantitative approach	"Huggable" social robot	Pediatric inpatient hospital setting	54	3–10 years	Hospitalized children with a range of diagnoses (including leukemia, other cancers etc.)	-
18	[20]	Quantitative and qualitative approach	"PHAROS 2.0" (PHysical Assistant RObot System Improved)	Care home	8	60–90 years	Elderly residents with varying levels of physical capability	-
19	[40]	Randomized controlled trial (RCT) (quantitative and qualitative approach)	Various assistive technologies (for mobility and daily activities)	Home settings	90 dyads (a care recipient and their family caregiver)	75 years average (for care recipients) 65 years (for caregivers)	Limitations in mobility or daily activities (osteoarthritis, cardiorespiratory conditions, neurological disorders etc.)	Family members or friends who provided unpaid assistance
20	[41]	Quantitative and qualitative approach	Assistive technology (tablets, smartphones, computers, wearable devices, and augmentative communication)	Online setting	96	-	-	Parents, guardians, caregivers, teachers, therapists of individuals with ASD/ID
21	[32]	Quantitative approach	Microsoft Band 2 smartwatch for collection of physiological data	Controlled experimental setting	19 (11 with Parkinson's disease and 8 healthy control subjects)	48–78 years	Mild to moderate idiopathic Parkinson's Disease	-
22	[24]	Qualitative approach	"AMiCUS 2.0" system, a robotic arm controlled by head motion using inertial sensors placed on the user's head	Controlled experimental environment	1	58 years	Progressed multiple sclerosis and tetraplegia, with severe head motion limitations and additional symptoms such as fatigue, attention deficit, and visual impairment	-

Table 2. *Cont.*

	Reference	Type of Intervention	Type of Assistive Technology	Setting	Sample	Participants' Age	Diagnosis (For Patients)	Expertise (For Professionals)
23	[25]	Preliminary evaluation	"Mini" desktop social robot	Nursing home	20 (10 elders, 7 caregivers, and 3 relatives)	NA	Elderly individuals, with potential cognitive impairments	Caregivers and relatives
24	[18]	Qualitative case study	"Pepper" humanoid robot and "CPGE" application	Psychiatric hospitals and geriatric health facilities	9	NA	Schizophrenia and/or dementia	-
25	[42]	Quantitative approach	Social robots (SRs) in rehabilitation and assistance	Online survey	323	23–58 years	-	Physiotherapists in training or working in the field
26	[43]	Qualitative phenomenological study	Wide range of devices (e.g., talking clocks, electronic medication dispensers, robotic vacuum cleaners, smart gas meters, audio books, etc.)	Interviewing at participant's own home or at the researcher's office, or over the telephone	23	42–91 years	-	Informal carers (family members, friends, or neighbors) of persons with dementia
27	[26]	Collaborative research methodology (qualitative approach)	"RoboTSS" robotic system designed to support clinical teams	Hospital	7	28–44 years	-	Nurses and anesthesiologist
28	[33]	Quantitative approach	Ambient assisted living (AAL) systems	Online questionnaire	174	19–68 years	-	Professional caregivers (in geriatric care, nursing care, and care/support of people with disabilities)
29	[44]	Qualitative approach	Intelligent assistive technologies (IATs) (AI, robotics, and wearable computing for healthcare)	In person and online interviews	20	NA	-	Professionals with expertise in gerontology, geriatrics, general practice, neurology, neuropsychology, nursing, nursing home management, and psychiatry

4.2. Challenges in Implementation of Assistive Technologies by Healthcare Professionals

Regarding the challenges that healthcare professionals face when implementing assistive technologies, in the study by [27], professionals from various areas of expertise reported that successful implementation requires access to portable, affordable ultrasound devices, adequate training, and sufficient time for practitioners to integrate POCUS (Point-of-care ultrasound) into practice. There is a need for enhanced training and education, particularly in community settings, where current training is limited. Support through remote reviews by experienced practitioners could also improve implementation. Proper governance, guidelines, and quality assurance are crucial for safe and effective use of POCUS in community care. Existing guidelines, primarily designed for secondary care, may need adaptation for community settings. They also noted that although POCUS devices are becoming more affordable, cost remains a consideration. The benefits of early diagnosis and reducing hospital visits could offset these costs.

In the study by [35], professional carers that participated in the focus group discussion pointed out the complexity of assistive tasks and their opinion that that a fixed user model for physically assistive robots is insufficient. The needs and abilities of older adults can change frequently, even within the same day, requiring continuous adaptation by the carers. The findings also suggest that, for assistive robots to be effective and safe, they must be capable of detecting and adapting to the hazards identified by human carers. Carers believe that the current technology lacks the necessary complexity to fully replicate the nuanced, adaptive care provided by human professionals. In another study that implemented robotics [17], caregivers and a former manager believed that the robot Pepper had several technical limitations, particularly in speech recognition and navigation. These limitations necessitated the use of a Wizard of Oz approach, where a researcher controlled the robot's responses, which could affect the overall user experience.

Participants from nursing care organizations identified several technical and operational challenges while using the Zora robot in the study in [38]. These included issues with Zora's start-up time, battery life, software reliability, and speech intelligibility. The Wi-Fi connection in some care organizations was also insufficient, which hindered the robot's performance. In [21], nurses highlighted several limitations of the care robots, including poor voice recognition, lack of interactive conversational abilities, and the need for constant human intervention to operate the robots effectively. These limitations sometimes led to frustration among both the caregivers and the older adults. Nurses also suggested that the technology should be made easier to use, with better conversational abilities and more intuitive interfaces. Improvements such as long-lasting batteries, easier charging systems, and more sophisticated voice recognition were also recommended. Similarly, another study [23] identified some challenges, including technical difficulties with the social robot Huggable and the need for considerable setup time and coordination.

Ref. [20] utilized PHAROS 2.0 in their research and the results were positive in general. However, the study identified areas for future improvements. Specifically, it was found that the feedback module needs enhancement to better emulate a therapist's role, particularly in handling critical errors during exercises that could impact user health. The complexity of integrating robots into existing team dynamics and the need for robots to understand the situational context of medical procedures was pointed out by healthcare professionals participating in the study in [26].

4.3. Ethical Considerations

Professionals who participated in the study of [27] emphasized the complementary role of POCUS. Specifically, they stated that POCUS should be used to complement, not replace, the work of radiologists. They also added that it could enhance physical examinations and assist in decision-making, but there was a risk of misdiagnosis if not properly managed. In [34], there was a neutral or slightly negative sentiment noted by the general population about robots potentially stealing jobs or performing certain personal tasks, such as caregiving.

Another ethical consideration was expressed by caregivers and a former care home manager regarding the study's participants. Specifically, they reported that participants developed a positive emotional connection with the robot, often treating it with affection. However, there were also concerns about the robot's limitations and the potential for automation to replace human interaction, which participants clearly preferred for personal care tasks. Similarly to other studies' findings, they also expressed their concern that interventions should ensure that robots are seen as complementary to, rather than replacements for, human caregivers [17].

Safety concerns and other observations were expressed in a study by [37]. Interestingly, although a full ATT (assistive technology and telecare) package was expected to reduce safety concerns, the study found that participants in the intervention group were more likely to move into institutional care due to safety concerns compared to those in the control group. This means that the full ATT package might have led to increased awareness of safety concerns, which could have paradoxically shortened the time for which participants were able to live independently.

The study in [22] identified several work-related threats that negatively impacted carers' acceptance of social assistive technologies. However, social assistive technologies could replace some job functions of human carers, which, carers feared, which could result in widespread adoption of social assistive technologies leading to job losses. Carers also feared that social assistive technologies would be used to increase management's monitoring of employees and this could result in a loss of autonomy of work. With respect to carers' perception of social assistive technologies, carers feared becoming over-dependent on technology, resulting in their loss of skills and confidence in performing tasks without requiring technological help. Moreover, the study indicates that perceived risk serves as an additional significant moderating role in the relationship between perceived usefulness, ease of use and the behavioral intention to adopt social assistive technologies. As perceived risks of use increase (by eliciting fears about the safety, privacy and even social acceptability of carers attempting to monitor someone), these technologies will be less compelling to carers. Finally, the study suggested that the aged care facilities should address carers' concerns about security job, autonomy, and over-dependence on technology.

A diverse group of people from the general population participated in the survey in [39]. The study highlighted that the impact of technology on well-being depended heavily on the balance between its positive and negative effects. When technology was used in a way that enhanced connections and supported daily activities without overwhelming the user, it contributed positively to well-being. Conversely, when technology use was excessive or poorly managed, it had detrimental effects. Participants reported that the overuse of technology led to issues such as increased screen time, physical health problems (e.g., eye strain, headaches), mental health challenges (e.g., anxiety, stress, loneliness), and expressed their concerns about technology addiction. They also emphasized feelings of fatigue and overwhelm from continuous online interactions and the blurring of work–life boundaries. Social interactions via technology were a double-edged sword, and while they helped people stay connected with friends and family, the lack of face-to-face interactions led to feelings of loneliness and dissatisfaction. Participants also noted difficulties in maintaining a work–life balance, increased stress from being constantly accessible, and issues with the effectiveness of online collaboration. The extensive use of these technologies sometimes led to addiction-like behaviors, with participants reporting that they spent excessive time on these platforms, which negatively affected their productivity and well-being. The pandemic drove a surge in the use of technology for information seeking, particularly related to COVID-19. However, while technology provided easy access to crucial information, it also exposed users to misinformation, leading to confusion and anxiety.

Ref. [18] suggested through their study that, while humanoid robots like Pepper could play a valuable role in rehabilitation and recreational activities for individuals with schizophrenia and/or dementia, they were not yet capable of fully replacing human caregivers. Concerns about social robots were also raised in [42]. Specifically, despite their overall positive view, physiotherapists identified some weaknesses of social robots in rehabilitation and assistance, particularly the lack of empathy and the risk of creating false relationships with patients. These concerns reflect the recognition that, while SRs can assist in technical tasks, they might struggle with the human aspects of care, such as emotional support. The study found that ethical issues were seen as potential obstacles to the widespread adoption of SRs. Participants believed that ethical considerations, such as privacy and the quality of patient care, would need to be carefully managed to ensure SRs are used appropriately. Ethical implications related to data privacy and the influence of AT on the social dynamics between carers and persons with dementia were brought out in [43]. Carers also voiced their concerns about the affordability of AT and its long-term effectiveness. In [26] six nurses and one anesthesiologist were worried about the potential for robots to bring about more challenges, such as privacy issues.

In [33], caregivers also expressed serious concerns about privacy and data security. The major barrier to the acceptance of these technologies was their potential to invade privacy and create a sense of surveillance. Technologies like emergency buttons and fall sensors were more acceptable to caregivers because they viewed them as less intrusive. However, cameras and microphones were rejected due to privacy invasion. Furthermore, caregivers were cautious about the type of data that could be gathered and who could access it. They were more comfortable with data related to emergencies but less accepting of continuous monitoring or storage of data over long periods.

The challenge of obtaining consent from patients with dementia, who may have diminished capacity to make decisions, was a significant ethical issue for professionals [44]. The use of advance directives and proxy decision-making were discussed as possible solutions. Concerns about data privacy, ownership, and sharing were prominent. Participants highlighted the importance of securing sensitive data collected by intelligent assistive technologies (IATs) and ensuring that patients have control over their data. A major issue was the cost of IATs and their access for all socioeconomic groups. The study raised concerns that creating such inequalities in access to these technologies could enhance the existing disparities in healthcare. People believed that IATs should complement but not replace human-delivered care. They stressed the value of having human empathy and interaction in caregiving, warning that over-reliance on technology could be detrimental to care. Furthermore, consensus was reached on how the ethical challenges presented by IATs should be dealt with, while there were dissimilar opinions as to how these should be resolved. This also included the ways to balance the social benefits from IATs versus associated risks to patient autonomy, privacy, and human interaction quality. The study revealed that it is very important to involve professional stakeholders in early stages of technology development to overcome ethical concerns from the beginning. It also recommended more user-centered approaches in the design of IATs to better meet the needs of older adults and their caregivers. Taken as a whole, these findings indicated a requirement for clear policies and governance regimes to resolve the ethical problems of IATs in dementia care. These would include having fair access to technology, protecting patients' autonomy, and building ethical considerations into designing and deploying these technologies.

4.4. Effects on Workload and Job Satisfaction

Several of the studies analyzed found relevant findings in relation to workload and job satisfaction. While POCUS had the potential to improve and speed up diagnosis, more evidence was needed, according to [27], to confirm the impact POCUS would actually have on patient outcomes and experiences in community settings. In [34], while participants were generally comfortable with robots assisting in work environments, they were less comfortable with robots performing more personal or sensitive tasks, such as caring for children or elderly parents. It is of note that the discomfort was consistent across all age groups. However, participants generally agreed that robots are beneficial for society, particularly because they can perform tasks that are too difficult or dangerous for humans. Informal carers in [28] reported that the voice-activated assistive device (Alexa Echo Show 8) not only supported patients but also eased caregiving responsibilities. This provided reassurance about the safety and well-being of the individuals being cared for, reducing the frequency of carers' visits or checks.

The professionals who worked with Zora generally reported increased job satisfaction and found the robot to be a fun and engaging tool. However, they also expressed frustration with the technical difficulties and the time required to start and operate the robot. The study highlighted the need for more extensive training and support to help professionals integrate the robot effectively into their care routines [38]. Nurses participating in [21] found socially assistive technology, including care robots, to be beneficial for continuing care during the COVID-19 pandemic, especially in providing non-contact care to older adults. They stated that the technologies helped in monitoring clients' activities and provided emotional support. However, they felt that the introduction of care robots increased the workload for nurses, as they had to manage the devices, teach older adults and their families how to use them, monitor their usage, and handle technical issues. This additional workload was particularly challenging during the already demanding COVID-19 pandemic.

Different findings were reported in another study [40], where both groups of participants (care recipients and caregivers) reported a significant reduction in caregiver burden over time, suggesting that assistive technology provision, regardless of caregiver involvement, may have beneficial effects. In [18], it was highlighted that robots can potentially ease the workload of health professionals, but human involvement remains essential for optimal care delivery. Physiotherapists who participated in [42] recognized several benefits of using social robots, including the potential to increase working capacity and facilitate better integration with other professionals. They saw social robots as tools that could help extend their capabilities, rather than replace their expertise. Informal carers of individuals with dementia expressed their opinions regarding the impact of technology on caregiver roles. According to them, the use of assistive technology influenced their caregiving roles, often adding to the carers' responsibilities, but also providing them with tools to enhance the care they provided [43].

Ref. [26] found that nurses envisioned using RoboTSS to challenge hierarchical power dynamics in clinical teams, particularly in scenarios where they were responsible for ensuring patient safety but might be hesitant to speak up due to traditional power structures. The robotic system was seen as a neutral third party that could enforce safety protocols and facilitate communication without the social complications of hierarchical dynamics. The study highlighted how RoboTSS could improve team coordination by managing roles, supporting real-time error identification, and providing automated guidance during resuscitation procedures. This would help to streamline workflows and reduce the cognitive load on team members, particularly in chaotic or emergency situations. However, despite the benefits relevant to workload and job satisfaction highlighted earlier, there were also concerns about robots becoming an additional layer of bureaucracy that might hinder rather than help clinical work.

4.5. Barriers and Facilitators for Patients and Professionals

In [16], ease of use and technology acceptance were the main facilitators for robotic technology implementation. Specifically, the ARNA robot was generally found to be useful and easy to use in a simulated hospital environment. Participants reported positive experiences in using the robot for both patient walking and patient sitting tasks. Additionally, the study used the technology acceptance model (TAM) to evaluate the perceived usefulness (PU) and perceived ease of use (PEOU) of the ARNA robot. The results indicated that the robot's design and functionality were well-received, suggesting that it could be successfully adopted in healthcare settings.

In [34] the perception that older adults are less receptive to robots is challenged. Specifically, the study showed that older adults, like younger and middle-aged adults, are open to robotic technologies, especially when these technologies are seen as supportive rather than replacing human roles. The acceptance of robotic interventions among different age groups would suggest nurses and healthcare providers expect similar acceptance of robotic interventions. This has implications in developing and deploying robots in healthcare, where it is crucial to understand patient attitudes in order to tailor interventions.

The health and social well-being of participants was improved with the use of a voice activated assistive device (Alexa Echo Show 8). For example, it helped in strengthening daily routines, for example by alerting people to take their medications and remember their appointments, which led to better treatment adherence and disease management. A study reported that the device helped make participants more independent, at least with daily chores. Additionally, it helped patients to avoid missing medication or appointments, particularly those associated with informal carers. For those living alone, it helped reduce loneliness and low mood, giving companionship by simple interaction, including chatting, telling of jokes, and playing music. During the COVID-19 pandemic, social isolation was a big concern, and the device was found to be particularly helpful. Lifestyle improvements, i.e., diet and exercise, were further supported by the device. Participants were able to access diabetes-friendly recipes, perform exercises, and engage in meditation and stress-relief activities, which contributed to better management of conditions like diabetes [28].

The study in [35] identified numerous hazards that occur during physically assistive tasks with older adults. These hazards vary based on the specific needs, behaviors, and physical or cognitive conditions of the older adults. Examples include failure to adapt the speed of tasks for patients with low blood pressure, misinterpretation of patient commands, and failure to provide appropriate support, among others. The study in [17] found that, while the robot was effective in facilitating activities, human moderation was essential for smooth interaction. A human moderator was also active in the discussion to give instructions regarding the activities, respond to technical concerns that might arise, and promote engagement, and the findings revealed that the effective integration of technology into care settings requires both humans and robotic components. The participants developed trust and followed the routine, as sessions were always conducted at the same time and place, thus reinforcing engagement. The main factors that supported the intervention included constant availability of the robot and the researcher.

Ref. [19] concluded, regarding the "Recommender" component of the PHAROS system, that it helped in providing an individualized exercise schedule matching the participant's strength and weaknesses. To do this, the system just had to alter its recommendations according to the performance and health of the participants; thus, the exercises recommended were safe and effective. The system was able to alternate between the exercises, so as not to cause boredom among the participants. Updating the PHAROS system to provide new sets of exercise recommendations, and avoiding the use of similar exercises consecutively, enhanced the participants' interest and confidence in the exercise regimes. The use of adaptive algorithms in the PHAROS system made it set better exercise recommendations, resulting from ongoing performance data. This helped to achieve the objective of interdependence in the different participants when performing the exercise routines, making sure the exercise routines were suitably challenging for the participants.

Challenges in the procurement process of assistive technology were documented in [36]. In particular, the most frequently reported barrier was the cost, and the second was the difficulty in obtaining funds to purchase new assistive technology. Lack of knowledge amongst clients about the available technologies and how to access and integrate them into provision processes, as well as providers' knowledge about the technology and the provision process were also determined to be barriers. Furthermore, general access to maintenance and repair was an identified issue, where the participants indicated that they failed to access adequate servicing for the maintenance and repair of their devices. Nevertheless, the study also described facilitators to the use of assistive technology. Some facilitators identified included the expertise of suppliers and providers, specific resources available through the Veterans Affairs (VA) system, and programs that provide funding or streamline the procurement process.

Based on the results observed in [29], the ElderTree system was able to reach a limited number of the population sample studied, therefore this can be viewed as a possible limitation. However, its implementation could result in significant advantages for certain groups, mainly for older people with a greater likelihood of utilizing health care and those with multiple comorbidities. A post hoc analysis suggested that the ElderTree system might be more effective for participants with multiple chronic conditions, as these individuals showed more positive outcomes in mental quality of life, social support, and depression when using the system.

One potential barrier for assistive technology implementation was reported in [37]. The authors found that the ATT intervention was not cost-effective. There were no significant differences between the intervention and control groups in health and social care costs or societal costs. Additionally, the participants in the intervention group had reduced participant-rated quality-adjusted life years (QALYs), at 104 weeks, compared to the control group, with a statistically significant mean difference of −0.105 QALYs (p = 0.037). The findings suggest that current approaches to implementing ATT in dementia care may need to be reevaluated, particularly regarding the matching of technology to individual needs and the support provided to both patients and caregivers.

Key facilitators for the successful use of Zora in [38] included the support provided by the project leaders' meetings, training sessions, and the availability of a helpdesk. These resources helped professionals overcome some of the barriers and share best practices. On the contrary, in [21] it was found that there was a need for more staff and better support systems to manage the increased workload associated with using care robots. Additionally, the study emphasized the importance of training healthcare workers in using these technologies effectively and called for greater governmental support to improve access to socially assistive technologies for older adults.

Perceived usefulness, ease of use and acceptance in care practices were identified as key factors influencing the adoption of social assistive technologies in [22]. Specifically, knowledge about the perceived usefulness and perceived ease of use was found to be important for carers' adoption of social assistive technologies. Technologies that were perceived as tools for lightening the workload of professionals were embraced. However, complex technologies that took a great deal of effort to become familiar with were not as acceptable. Carer's attitudes towards using social assistive technologies were influenced by perceived usefulness and perceived ease of use of the technology. Nevertheless, this perception was moderated by perceived risks and work-related threats. Overall, increasing the use of social assistive technologies in the context of aged care might be possible through giving sufficient emphasis to training, compatibility with current practices, and reassurances about job stability and safety.

Practical challenges with technology that served as barriers in implementing assistive technology were mentioned in [39]. Participants reported practical issues such as poor internet connectivity, hardware malfunctions, and the inadequacy of some digital tools for certain tasks. These challenges often exacerbated the negative effects of technology use. In [30], the mean search times of the Touch Talker digital text-to-speech system decreased in the second trial, indicating that the device became easier to use with practice. However, despite the overall effectiveness, some challenges were identified, particularly with the tap control function of the device. For instance, some participants had difficulty determining whether their finger was on a letter, a space, or a blank line. This lack of responsiveness sometimes caused frustration and affected performance. Based on the findings, the researchers suggested improvements to the Touch Talker device, particularly in enhancing the tap control function and the responsiveness of the screen. These improvements aim to make the device more user-friendly and effective for visually impaired users.

In [31], it was reported that participants generally knew where to find information about assistive technologies (ATs), but healthcare providers were not their main source of this information. This suggests a potential disconnect between healthcare providers and patients regarding AT information dissemination. Furthermore, this low awareness could contribute to the limited use of these technologies. The study highlighted several barriers to the adoption and use of high-tech ATs. The first was poor awareness, as limited knowledge about specific devices hinders their adoption. The second was access issues: despite knowing where to find information, participants were not actively seeking it out, possibly due to accessibility issues or a lack of interest. The last was user experience, since there was a gap between functional effectiveness and user experience, with participants expressing concerns about the usability, aesthetics, and practical benefits of some devices.

Ref. [20] highlighted some facilitators for assistive technology use. The system used provided real-time feedback to users during their exercises, which helped them correct their posture and movements immediately. The Recommender system, which is part of PHAROS 2.0, was able to suggest appropriate exercises based on the user's performance, temporal evolution, and preferences. This personalized approach aimed to keep users engaged in their exercise routines and promote active aging. User satisfaction was high, as reflected in the System Usability Scale (SUS) questionnaire responses. Participants found the activities engaging and enjoyable, which is crucial for ensuring long-term adherence to exercise programs in elderly populations. Ref [41] considered assistive technology accessibility and effectiveness as facilitators for implementation. Participants rated their experiences with assistive technology positively overall, particularly in terms of ease of use and accessibility, although cost-effectiveness received lower ratings. However, there were some barriers to independence. The survey identified communication deficits, lack of service provision, self-management skills, and cognitive and social skills as significant barriers to independence for individuals with autism spectrum disorders and/or intellectual disability.

In [32], a comparison was performed between persons with Parkinson's disease (PwPD) and a control group. The study observed that arousal classification accuracy was lower for PwPD compared to the control group. This difference was attributed to autonomic dysfunctions commonly seen in Parkinson's disease, which may affect the physiological signals related to arousal and serve as a barrier for implementation. On the other hand, valence classification accuracy was higher in PwPD than in the control group, suggesting that the algorithms could better distinguish positive and negative emotions in PwPD based on the physiological signals collected.

Positive user feedback was reported in [24]. The participant provided positive feedback regarding the ease of use, the simplicity of the new switching process, and the improved visual interface. The study noted that the user appreciated the system's accessibility, finding it easier to control the robotic arm over extended periods without discomfort. Also, the system's flexibility was highlighted, with the ability to adapt to different levels of user skill and head range of motion (ROM). This adaptability could possibly make AMiCUS 2.0 suitable for a broader range of users with varying degrees of disability. Nevertheless, some issues were identified, such as difficulties in interpreting the camera image when the robotic gripper was not upright and occasional confusion when the system deactivated robot control after quick movements. These observations suggest areas where future iterations of the system could be further refined.

The robot's appearance was considered as a facilitator for implementation in [25]. The Mini robot was well-received in terms of its appearance. It was perceived as friendly, smart, and safe, with a slightly more mechanical than human-like appearance. However, there was room for improvement in making the robot appear more lively. Some barriers during interventions were reported as well. Despite the overall positive feedback, participants did not fully perceive the robot as a tool that could significantly increase their autonomy or reduce the demand for care from caregivers. This indicates that, while the robot was appreciated, its potential to enhance independence may need further development or better communication to users.

Barriers regarding robot-based interventions were also mentioned in [18]. More specifically, the authors reported that some patients experienced difficulties in understanding or hearing the robot. In addition, the robot's limitations in handling complex or extended conversations were noted, indicating that while beneficial, the robot's current capabilities are somewhat limited. Therefore, the need for health providers to support and guide patients during these interactions was highlighted, indicating that while the robot can initiate and guide activities, human oversight is still crucial. Overall, the study identified several areas where the Pepper robot's performance could be improved, particularly in enhancing communication and interaction capabilities. These limitations suggest the need for further development in robotic technology to better meet the needs of patients with severe cognitive impairments.

The study in [43] provides insights into the complex experiences of carers using assistive technology in the context of dementia care, highlighting both the benefits and challenges associated with its use. Specifically, carers faced challenges in acquiring and continuing to use assistive technology, especially as the dementia of the person they were caring for progressed. There were also issues related to the cost of assistive technology, design flaws, and the need for better support and training for carers in using these technologies. In [26], several design implications for developing robots like RoboTSS were proposed, emphasizing the need for these systems to be adaptable, context-aware, and capable of enhancing rather than complicating team dynamics. The goal is to ensure that such systems genuinely support and empower healthcare professionals, particularly in high-pressure environments like hospitals. Finally, another potential barrier for implementation was highlighted by [33]. In this study, caregivers with higher technical confidence were more accepting of AAL systems, while those with greater privacy concerns were more critical.

5. Discussion

The increasing integration of assistive technologies into healthcare, particularly for elderly and vulnerable populations, has highlighted both the potential benefits and challenges associated with their use. Technologies such as care robots, socially assistive devices, and AI-based platforms have been explored in various contexts to improve quality of life, enhance independence, and reduce the burden on caregivers. However, findings across the studies included in this discussion illustrate a complex balance between technological promise and real-world implementation challenges.

The discussion surrounding the implementation of AT and eHealth platforms, such as those in AAL systems, has been mixed, highlighting both the promise and limitations of these solutions for supporting independent living among older adults and individuals with chronic health conditions [33]. Studies such as [37] suggest that, while AT and telecare (ATT) solutions offer potential in monitoring and improving the safety of individuals with dementia, the actual effect on postponing institutionalization was minimal. The randomized controlled trial did not show significant benefits in extending the time for which individuals with dementia could live independently, nor was it cost-effective, thus raising questions about the real-world utility of such technologies in dementia care [35]. In [25], although participants generally provided positive feedback, they did not fully view the Mini social robot as a device that could greatly enhance their autonomy or lessen the need for caregiver support. This suggests that its ability to boost independence may require further development or clearer communication to users.

However, in another study, participants noted that the Alexa Echo Show 8 device enhanced their independence by helping with daily activities and lessening their dependence on others. It also eased worries about forgetting medications or appointments, offering reassurance to both patients and their informal caregivers [28]. Similarly, [19] reported that the PHAROS system gave participants a sense of autonomy, which positively impacted their overall well-being.

Another key theme emerging from the literature is the potential of socially assistive robots (SARs) and other intelligent assistive technologies (IATs) to enhance patient care. Studies such as [42] highlight how social robots can assist in rehabilitation and care by improving interactions and increasing patient engagement. The physiotherapists surveyed in the study expressed positive opinions about the integration of these devices, viewing them as complementary tools that could increase their working capacity and aid in monitoring performance. Similarly, [43] reported that the use of a wide range of assistive technology devices could help professionals in their caregiving roles, despite adding new responsibilities.

Similarly, while tools like RoboTSS and the BrainPort Vision Pro offer groundbreaking possibilities in providing medical and sensory assistance, their real-world applicability often faces challenges. RoboTSS, for instance, was designed to improve the coordination of healthcare teams and mitigate medical errors, but the complexities of integrating robotic support into high-stakes environments like hospitals raise concerns around trust, usability, and adaptability to dynamic human needs [26,31]. Devices like BrainPort Vision Pro and The vOICe also require substantial training and cognitive load for users to adapt to, which can hinder widespread adoption, despite the technological advancements. The Pepper robot, despite being a promising tool for healthcare settings, had several limitations that hindered interactions with patients, such as the inability to follow more complex conversations [18].

On the other hand, systems such as ElderTree, which promote self-determination and social connectivity for older adults, have shown positive impacts on mental health and social support, particularly for individuals with higher healthcare needs. However, these benefits are often more pronounced in targeted populations, and the overall efficacy of such systems can vary significantly, based on individual circumstances [29]. The Microsoft Band 2 and similar wearable technologies have been effective in collecting physiological data and facilitating health monitoring, but these devices have been phased out, leaving a gap in accessible, non-invasive tools for continuous health tracking [32]. Another study reported the ease of use and the simplicity of AMiCUS 2.0, thus highlighting its accessibility [24].

One prominent theme is the benefit of socially assistive technologies and care robots, particularly in reducing social isolation and promoting well-being among older adults. For instance, [21] highlighted the positive impact of AI-based smart speakers like Aria and interactive services like Care Call during the COVID-19 pandemic, emphasizing their role in providing emotional support and facilitating daily care tasks for older adults. Similarly, [38] found that the Zora robot, a humanoid social robot, improved mood and engagement in elderly patients in Dutch nursing homes. In another study, technology enabled individuals to stay connected socially, supported remote work and education, offered entertainment, and provided access to information and services. Many participants shared that using technology during the pandemic helped them manage feelings of isolation and preserve a sense of normalcy [39]. These technologies were particularly useful during the pandemic when physical contact was limited, demonstrating their potential in maintaining communication and care at a distance [20,39].

Another critical issue is the technical limitations and usability challenges associated with these technologies. Many studies, including [21], point out that, while AI-based devices like Care Call and Aria smart speakers can assist in managing tasks for elderly individuals, their effectiveness is often hindered by issues such as limited voice recognition and inadequate interaction capabilities. Also, care robots like Silbot were limited in their ability to engage meaningfully with users, requiring human intervention to perform basic tasks. Similar limitations were echoed in studies utilizing the Zora robot, where healthcare professionals reported software failures, start-up issues, and additional workload associated with managing the device, leading to concerns about its long-term sustainability in care. Another study involving a robotic tool identified challenges for the participants, such as technical difficulties while interacting with the robot and extended durations for setting up daily care [23,38].

In [39], participants mentioned practical challenges, including unreliable internet connections, hardware issues, and the unsuitability of certain digital tools for specific tasks. Ref. [30] reported problems regarding a specific control function of the device, which caused frustration to the users. These technical barriers can not only reduce the efficiency of the devices but also increase the workload of caregivers, who are required to provide additional support to ensure the devices function properly [21,38].

In [21], it is noted that nurses faced additional tasks, such as teaching patients and their families how to use the devices, monitoring usage, and troubleshooting issues, all of which contributed to a heavier workload [21] Similarly, the Zora robot's deployment was associated with increased responsibilities for caregivers, including setting up and maintaining the device, which, at times, detracted from direct patient care [38]. This suggests that, while assistive technologies can supplement care, they do not necessarily reduce the workload and may require additional staffing or resources to be effective.

Furthermore, cost-effectiveness and accessibility remain ongoing concerns. In [41], results regarding assistive technology accessibility and effectiveness were overall positive. Although the potential for reducing caregiver burden and enhancing patient independence is widely recognized, the actual implementation of these technologies often falls short due to financial constraints. As noted in [37], ATT solutions did not significantly extend independent living times for dementia patients, raising questions about their cost-effectiveness and practical utility in real-world settings. This is consistent with the findings in [44], which highlight the issue of distributive justice and the affordability of assistive technologies, particularly in dementia care, where access to such technologies can be limited by financial and systemic barriers. Cost-effectiveness and accessibility are crucial considerations, as financial sustainability is a key factor in the broader adoption of such technologies in healthcare settings. Ref. [27] emphasized the decreasing costs of portable ultrasound devices, which could facilitate wider use of POCUS in community settings. This mirrors [36], which discussed how the high cost of assistive technology, coupled with insurance barriers, limits patient access.

Despite these promising findings, significant ethical and practical challenges remain, particularly regarding patient autonomy, informed consent, and data management. Ref. [44] addressed these concerns, noting that the use of intelligent assistive technologies in dementia care raises ethical issues related to autonomy, privacy, and the potential for deception. For instance, patients with cognitive impairments may struggle to provide informed consent, and the introduction of socially assistive robots could blur the lines between human and machine interactions, potentially leading to ethical dilemmas regarding patient dignity. This concern is mirrored by findings in [17], which explores how humanoid robots like Pepper, while beneficial in certain therapeutic contexts, must navigate complex ethical landscapes, particularly when dealing with vulnerable populations.

In [34], participants largely agreed that robots offer societal benefits, especially by taking on tasks that are too challenging or hazardous for humans. However, opinions were neutral to somewhat negative when it came to concerns about robots taking jobs or handling personal tasks, such as caregiving. Ref. [22] identified several work-related concerns that affected carers' acceptance of social assistive technologies. These included fears of job replacement, as the technologies could take over some tasks; concerns about increased employee monitoring, which might reduce their work autonomy; and worries about becoming overly dependent on the technology, potentially weakening their skills and confidence. Additionally, perceived risks, such as safety, privacy, and social acceptance, moderated carers' willingness to adopt the technology, with higher perceived risks reducing their likelihood of using it. Data privacy issues have been found when implementing assistive technology in healthcare, along with other issues [43].

In conclusion, while assistive technologies such as care robots, smart speakers, and telecare systems offer promising tools for enhancing care and reducing social isolation among older adults, their real-world application is fraught with challenges. Technical limitations, increased workload for caregivers, and questions of cost-effectiveness need to be addressed to realize the full potential of these innovations. The advantages of the use of social robots and intelligent systems in patient care and self-management are important, but there are significant barriers to the general application of technology for these roles on a regular basis. Further research should be conducted on enhancing the accessibility as well as the dependability of these technologies, and informative and sufficient support should be offered to caregivers to help them utilize those technologies in practice.

Altogether, the use of assistive technologies in healthcare settings can only be compared to the profound understanding of ethical aspects and concerns. In this way, transparent algorithmic processes, privacy regulation, bias or discrimination can all be addressed to help stakeholders make certain that technology is used properly. This study emphasizes the importance of individually oriented and personalized strategies in the development and use of assistive technology systems. It is suggested that future directions should target enhancing the flexibility of these technologies for improved alignment with the needs of the users in real-life settings. Furthermore, issues of usability, training, and acceptance must be addressed to ensure that these innovative solutions can fulfill their potential in supporting independent living and enhancing quality of care.

6. Conclusions

This study investigates the difficulties and moral dilemmas associated with incorporating assistive technology into healthcare environments, with particular attention paid to patient privacy, data security, and the effects on caregivers. In order to overcome these obstacles and promote the use of new technologies, the paper also looked for answers. Through a methodical review of the literature, the paper shows important aspects of the use of assistive technology.

According to the findings, assistive technologies—such as wearable technology, care robots, and AI-powered gadgets—have a big impact on enhancing patient care and encouraging independence. Technical restrictions, financial fears, and moral challenges—particularly those relating to privacy and an excessive dependence on automation—often hinder their implementation. The paper shows that, despite these obstacles, when used carefully, these technologies can lessen the strain on caregivers, improve patient participation, and encourage independent living. Additionally, the findings imply that, although assistive technology can enhance human care, it cannot completely replace the complex, compassionate interactions that healthcare providers offer.

This limitation encourages solutions that balance the efficiency of these tools with the preservation of human-centric care. For example, socially assistive robots like Zora and platforms such as PHAROS have demonstrated the potential to improve patient outcomes, but their usability and acceptance is based on adequate training, user-friendly design, and supportive governance structures. The requirement for ongoing human supervision, budget, and variations in user approval are major obstacles. Policymakers, healthcare professionals, and IT developers are just a few of the stakeholders who will need to work together to close these gaps. Future studies should concentrate on developing flexible, affordable solutions that meet the needs of a wide range of users and include moral considerations throughout the entire process of developing new technologies.

The findings of this paper show the need for a multidisciplinary approach to address the obstacles associated with the deployment of assistive technology. Patient well-being and care quality can be greatly improved by these tools by addressing privacy issues, guaranteeing affordability, and encouraging user adoption. To successfully implement assistive technology in healthcare in the future, it will be essential to incorporate strong ethical standards and inclusive design principles.

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