Humanoids at the Helm of the Nursing Profession in Elderly Care: Critical Review

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Abstract. Older persons and carers benefit from the use of healthcare robots. Many scientists and academics have looked at using robotic technology to assist both elderly individuals and their caregivers. We provide a contemporary overview of care robotics through a survey of the literature and an in-depth analysis of published articles. We discuss what we know about the use of assistive robots in elderly care, their benefits, and potential hurdles in this research. We investigate how assisted healthcare robotics can help to shift the nursing function's unsettled resource-demand balance. We review recent research on the use of care robots from a sociotechnical viewpoint, which examines human-machine interactions and focuses on results that may or may not be beneficial to the setting. Principles of responsible autonomy and adaptation with the goal of performing tasks that are meaningful. These humanoid resources perform a variety of physical, cognitive, and social duties in order to help people live healthier lives. We concentrate on the current and future difficulties of healthcare robots, as well as how such technology might benefit healthy aging, healthcare personnel, particularly nurses, and our healthcare system as a whole. Despite the potential benefits, we conclude that adoption of care robots is still limited. We pave the road for identifying elements of adoption that may influence the adoption process using the sociotechnical lens.

Keywords: Elderly care · Nursing care robots · Assistive healthcare robotics

1 Introduction

An aging population poses significant challenges to health and social care systems with limited resources. People around the world are living longer and the population growing at a rate of around 1.05% per year. The current average population increase estimates at 81 million people per year[1]. The trend is such that, by 2050 there will be more people over 60 than under 15, with a total population of seniors jumping to 2.1 billion up from 901 million in 2015[2]. There might not be enough people to care for elderly in the future. For instance, Western Europe's population over 60 years old will increase from 21% in 2015 to 33% by 2030, while the available health worker per elderly citizen is

[1] https://www.worldometers.info/.
[2] https://www.un.org/development/desa/disabilities/disability-and-ageing.html.

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expected to drop from 3.5 to 2.4, which is also 30%, however, in the opposite direction[3]. When society's age structure shifts, a smaller number of trained caregivers and other practitioners would be required to care for a growing elderly population, extending the stress on the nursing professionals.

The nursing profession employs the highest proportion of the healthcare workers; nurses are the backbone of the industry [1–3]. The continuous nursing shortage, combined with a high turnover of nurses and support staff at elderly-care facilities [4], has resulted in unresolved healthcare and social concerns that constitute significant barriers to integrated nursing care services [5, compromising the safety and quality of treatment]. Nurses have reported increased stress [5], emotional weariness, a lack of motivation, and a sense of dissatisfaction [4] as a result of their unsustainable workload. One technique that is gaining traction in an attempt to provide technology help to the nursing function is the use of robots in the care of old persons [6–8].

1.1 Motivation

Healthcare robots are beginning to take center stage in supporting older persons in maintaining their autonomy and caring obligations, as well as compensating for the absence of carers [9]. Robotics technology, which is powered by artificial intelligence, has made great progress in recent years [10] in a range of industries, including healthcare [14]. Elderly people can live independently at home with the help of robots, and healthcare workers can work more efficiently in hospitals. Assistive technologies have been hailed by the elderly, health care workers, family members, and the general public. While there is still a low demand for care robots for the elderly and disabled, it is expanding rapidly as robot applications improve and become more user-friendly [11]. The industry forecasts that 79 million homes, globally, will have a robot in residence by 2024[4]. Despite their amazing capabilities, the use of care robots in nursing is currently uncommon. What role do assistive healthcare robots play in nursing? What are the possible advantages in terms of utilization and positive outcomes? What does the literature say about the problems and drawbacks of using care robots in nursing? The answers to these questions may aid in the understanding of the design principles required for a better task-technology fit [47] in the context of patient care for the nursing function.

2 Background

Our research is a conceptual investigation into the phenomenon of assistive technology, specifically assistive healthcare robots, for the nursing profession in their care of elderly people and caregivers, using a sociotechnical system (STS) approach. The observation of sociotechnical aspects through the eyes of the impacted stakeholders ensures the creation of a long-term system of interaction that is both engaging and beneficial to all parties concerned [12]. The interconnectedness of social and technical aspects of an

[3] https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Highlights.pdf.

[4] https://www.industryweek.com/technology-and-iiot/article/22028128/79-million-homes-globally-will-have-a-robot-in-residence-by-2024.

organization or system is referred to as sociotechnical theory (ST) [48]. Often depending on technology to promote a smart connection with society, ST provides tools to improve the performance of work systems by understanding how human actors' actions affect the system's performance.

We hope to learn about potential benefits in use and positive outcomes, as well as revisit a summary of barriers and downsides to the use of care robots in the nursing role, through this effort. We create a contextual overview of assistive care robots, then conduct a critical assessment of the literature to uncover the sociotechnical phenomena. We establish a decision plan for where to search, which phrases and sources to utilize, and how to find relevant research, among other things, as we prepare for our critical evaluation. Two searches are carried out. The first concentrates our attention on the various applications of assistive care robots in senior care and nursing (Sect. 2.2). Then, for the second search, we emphasize on what the literature says about current and potential benefits, potential challenges and drawbacks. The search encompasses online databases including but not limited to EBSCO, PubMed, Google Scholar, identifying and isolating key informative papers for our study. Then we arrange our results under themes, revealed in paragraph 3. Finally, we provide some reflection on the findings and close with comments and suggestions for further research prospects.

2.1 Assistive Healthcare Robotics and the Sociotechnical System Perspective

Assistive technologies are devices that are used to improve the efficiency and efficacy of healthcare by enhancing the organization's and people's capacities to complete tasks [49]. Current breakthroughs in care robotics are founded on this basic concept. The fundamental hypothesis, which is based on sociotechnical systems theory [50], is that the technological components of a device's design will have an impact on its users (Fig. 1). This puts a strain on the operators' perceptual, cognitive, and motor capacities, and as a result, unfavorable results are possible, especially when workers are fatigued, which compromises human potential [51].

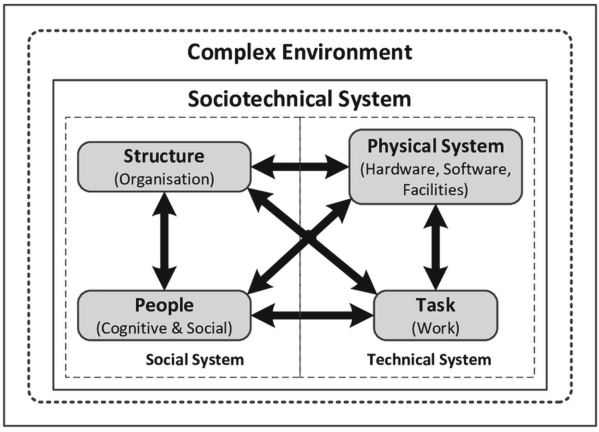

Fig. 1. Sociotechnical system (STS) – [50]

2.2 Elderly Assistive Care Robots Join the Nursing Job Function

Closer to the nursing function, assistive technology is expected to play a rising role in elderly-care systems [13], despite the fact that there are various feasible alternatives, ranging from better paying, valuing, and professionalizing caregiving to current community nursing models [8]. Assistive technology aims to improve people's functions, consequently improving their well-being [14]. Robots have made their way out of operating rooms in recent years to help with diagnosis, therapy, recuperation, and nursing [5, 15, 16]. Varieties of robots that assist the elderly are currently available in a variety of applications [17].

Those who care for the elderly benefit greatly from the use of robots [18]. Nursing robots can do routinely planned rounds and provide a pleasant reprieve to the nursing staff because they are not vulnerable to weariness, boredom, burnout, or amnesia [19]. For example, they save time and effort for healthcare staff while also providing vital patient information [20]. In response to the current lack of nursing and caregiving practitioners, as well as rising healthcare expenses, a variety of technological solutions have emerged [21]. Because robots, by definition, connect with and impact their surroundings [22], it has become vital to develop care robotics for and by nurses [5].

Monitoring vital signs, improving communication with family, and providing medication reminders were the most popular jobs and applications for robots in the previous decade [23]. According to Lee et al. [5], the top three nursing tasks that robots could assist with are "measuring/monitoring," "mobility/activity," and "safety treatment," with the most popular robot tasks being "detection of falls and calling for help," "lifting," and "location monitoring," while healthcare professionals preferred the use of robots in service tasks, monitoring/alarms, telemedicine, and communication. In home health monitoring robots are used to track physical health status (weight, sleeping patterns, high blood pressure, and so on) utilizing clinical and medical information, with the goal of informing the patient and making the caregiver's job easier. Fall detection and prevention robots are among the health monitoring robots that can detect and avert falls [18]. Other domotic devices include reminder robots, which are designed to keep older persons on track with their medicine and appointments, and entertainment robots, such as card-playing robots that enhance cognitive abilities and memory function [18].

Assistive robots are defined in the literature as partially or entirely autonomous robots that conduct care-related duties for people with physical and/or mental disabilities as a result of age and/or health limits [4, 11]. They've evolved to help nursing personnel, older individuals, and their families in care settings when providing physical, cognitive, or emotional support [14, 22]. They have the potential to improve the quality of life for the aged and/or handicapped by boosting autonomy, providing security [11], and improving cognitive function and depression [5]. Until date, elderly robots have mostly assisted with daily activities, allowing for detailed real-time tracking of habits and wellbeing, as well as companionship [14]. The literature attests to the importance of the subject. Physically or surgically helpful robots account for the majority of robot utilization in the healthcare industry, but they do not address the rising mental health burden among the elderly [2]. Physically assistive robots introduce support for daily physical activity to improve the overall health of the elderly [18], while socially assistive robots maintain

social contact through companionship, which has a positive effect on general mental and physical wellbeing, lowering the chances of depression [24].

Physically Assistive Robots (PARs) are service robots that help older individuals with daily duties [25]. They include smart houses with a variety of technologies that let patients stay autonomous by assisting them with simple activities [30]. Sensory assistive robots and robotic wheelchairs for mobility aid with manipulators for reaching and carrying, personal care, eating and drinking [18]. Rehabilitation robots (e.g., Physically-Assistive Robots, PARs, such as Zora) targeted to increase movement performance [16, 20, 26]. They were designed for recovery training and agility improvement. Finally, mixed aid robots are the most entertaining of all. Domestic chore robots, such as cleaning and cooking, are aimed to aid the elderly in doing simple tasks of independent living [18].

Socially Assistive Robots: Companion robots used to boost one's psychological well-being are known as Socially Assistive Robots [30]. Robotic technology systems with audio, visual, and movement capabilities are known as socially assistive robots. They are frequently shaped like a pet (cat, dog, etc.) or a humanoid that can listen, converse, touch, and sense light and sound [18]. These robots are capable of assisting people during social interactions. They provide a physical embodiment that boosts likeability, commitment, motivation, adherence, and task performance in long-term healthcare programs. Furthermore, by evaluating and providing feedback, they assist patients in using physiological parameters [16, 27, 28]. These "Companion robots" have been related to enhanced mental health in terms of stress reduction, agitation, and relaxation [25, 26, 29, 30].with decrease in care provider burden [8, 20, 29, 31]. For more than a decade, conversational robots have been conversing with people demonstrating levels of empathy in their encounters with humans [32]; a robotic contribution, shown to improve the overall well-being of its users [2]. Other Socially assistive robots help with autism patients and often used for telepresence make two-way contact possible between the older adults and their surroundings.

3 State of the Literature

There is a dearth of material about assistive care robots at the head of the nursing profession in senior care. Nonetheless, our critical examination discovered a number of concepts relating to potential benefits in use (Reported Value in Use), as well as a number of potential challenges and drawbacks affecting the user's experience, which we labeled as emerging themes in Table 1:

3.1 Potential Benefits in Use

Several possible benefits of deploying social robots in the care of the elderly have been thoroughly investigated. According to research, the majority of older people's attitudes are positive, and they are delighted to have a robot aid them in their daily lives [8, 14] and appreciate the benefits. Cost-effectiveness, satisfaction with care, reduction in incidences of violence, physical safety, security for personal privacy and integrity, psychological

Table 1. Summary of the state of the literature – Illustrative example

Reported Value in Use – With Examples from the literature	
Better Access to Care	• Extend benefits of care in remote areas [45, 46]
Cost-effectiveness	• Significant economic benefits and cost reduction [17] • A robotic device can save money by reducing labor costs and performing tasks that humans may find repetitive. [34]
Satisfaction of Care	• Enhance physiological/psychological state of patients [17] • Improve quality of life by increasing autonomy/security [11]. Comfort disclosing information to virtual humans [35]
Reduction in Incidents of Violence	• Reduce the risk of physical/ sexual violence [31] • Less irritable/less likely to induce emotional stress [8]
Physical Safety	• Logistical or surveillance tasks in the care environment [22]. Sentinels for physical safety in sensing fall risk [16, 20, 26]
Personal Privacy	• Care robots as agent of personal privacy and dignity [8, 32]
Psychological Benefits	• Improved social interaction [36], empathy [32], stress reduction, agitation and relaxation [8, 25, 26, 29, 30]
Decrease in Care Burden	• Decrease in care provider burden – Physical and psychological [8, 20, 29, 31]
Potential Challenges & Drawbacks - with examples from the literature	
Potential Risk of Injury	• Malfunctions or lack of upkeep may lead to injuries [8, 16]
Perceived Loss of Control	• Feeling of even loss of control [20]
Isolation Risk	• Effect of reduced human contact and social interaction [8, 20, 29]; risk of surveillance anxiety [15, 20]
Ethics Issues	• Feeling of unreal empathy [8, 29, 32]
Technical Annoyances, Cost of Acquisition, and Maintenance:	• Lack of technical knowledge was perceived as a barrier to technology adoption [38]. High cost of most devices [20]. Potential anxiety caused by klunky or loud noises [20, 28]
Communication Disruption among Care Personnel:	• Hinder clinical staff communication [2]; Perception of the technical staff on the humanoid's lack of compassion [29]

(*continued*)

Table 1. (*continued*)

Reported Value in Use – With Examples from the literature	
Perceived Impact on the Nursing Career:	• Fear of robots taking the place of human [39], which could change the character of society [20]. Balance between workload reduction and maintaining human touch [8]

benefits, and a reduction in care burden are some of the advantages of deploying care robots in nursing.

Better Access to Care: Elderly persons who live alone are more prone to falls and accidents, and they often have difficulty accessing health care when they need it. The employment of intelligent care-providing equipment increases access to speciality care services that may not be available in the patient's location [45]. People who live in locations where there aren't many mental health professionals, for example, can benefit from interactive virtual human care providers [46]. Virtual care provides information about health conditions, conducts question-and-answer assessments, and provides self-care counseling and therapeutic interventions. It is accessible anywhere and at any time, including on mobile devices.

Cost-Effectiveness: The development of intelligent machines in healthcare has the potential to deliver considerable economic benefits to healthcare providers and services for an aging population, in addition to improving patient outcomes and quality of treatment. These robotic care providers can help government programs or care-assurance budgets save money [17]. Software-based intelligent devices, by bringing the economies of scale to care delivery, can help to offset the estimated global cost of care, which is expected to exceed $6 trillion dollars by 2030, according to a World Economic Forum analysis. In general, a robotic device can save money by lowering labor expenses and automating jobs that humans find tedious. However, it's probable that the cost of human resources to maintain and run the system will rise as a result of the required capital investment to sustain quality care levels [34].

Satisfaction of Care: Important potential benefits of social robots in care are related to structure (efficiency) and outcome; they have the ability to improve both physiological and psychological variables, as well as the satisfaction of those who are cared for [17]. Human therapists may be viewed as having personal prejudices, but care robots may not. It has the potential to make daily activities easier for the aged and/or crippled, increase autonomy, and provide security [11]. Robots may appear to be always friendly and available. When discussing intimate, private matters with a computer, care seekers may feel less anxious than they would with another person. Others may feel more at ease providing information to virtual persons during clinical interviews and prefer to interact with them over medical personnel [35]. For example, a virtual nurse could adapt their demeanor (e.g., eye contact), spoken dialect, use of common terms, and other features to fit the needs of a certain ethnic group, allowing them to build rapport with patients and improve overall communication.

Reduction in Incidents of Violence: Physical, sexual, psychological, financial, administrative, performance, and neglect are all common forms of violence experienced by elderly patients in care homes. Robots have been demonstrated to lower the danger of physical, psychological, and sexual assault by providing 24 h care without tiring or becoming irritable, and are less likely to exhibit any of the negative personality traits associated with human employees [8].

Physical Safety: In addition to reacting to persons in the care setting, these devices can perform logistical or surveillance activities [22]. Residents may be able to give comments on whether or not they prefer being treated or touched by robots. Robots can also serve as sentinels for physical safety, monitoring the risk of falling and promoting movement performance [16, 20, 26].

Security for Personal Privacy and Integrity: When our freedom is threatened, some of us are more likely to consider, or even prefer, the assistance of a care robot [32]. Older adults particularly those with intellectual disabilities, need ongoing assistance with everyday activities such as toileting, showering, and dressing without feeling undignified or embarrassed (if naked) by another person assisting in his or her intimate tasks, even if that person is a nurse. They may reduce the functional burdens of coping with incontinence, wandering, and uncertainty [8]. Thus, the use of robots could be an agent of personal privacy and dignity.

Psychological Benefits: Some of us are more likely to contemplate, or even desire, the assistance of a care robot when our freedom is threatened [32]. Even if the person assisting in his or her intimate tasks is a nurse, older adults, particularly those with intellectual disabilities, require ongoing assistance with daily activities such as toileting, showering, and dressing without feeling undignified or embarrassed (if naked) by another person assisting in his or her intimate tasks. They may help people cope with incontinence, roaming, and uncertainty in a more practical way [8]. As a result, the deployment of robots may be a safeguard for personal privacy and dignity.

Decrease in Care Burden: The use of social robots has also been linked to a reduction in caregiver load [8, 20, 29, 31]. These robots can also help relieve some of the psychological strains on professions, particularly for overwhelmed family members and informal caregivers who are witnessing their loved ones' capacity erode, creating a great deal of distress.

3.2 Potential Challenges and Drawbacks

In contrast to the benefits, the literature outlines current challenges associated with the use of assistive robots, such as the risks of moral hazard concerns related to unintended changes in direct relationships between robots and older adults, such as control, isolation, deception, and impact on the nursing career [8], as well as a widespread fear of dehumanization in society.

Potential Risk of Injury: Robot interactions can be dangerous. Any failures or a lack of regular maintenance that could result in an accident or injury [8, 16]. When robots are employed for purposes other than therapy, such as turning patients in beds or bathing them, the problem becomes even worse. Another factor to consider is the usage of sex robots in nursing homes, which would demand extra precautions. Failsafe devices are necessary, which detect and adjust the behavior of malfunctioning robots [8].

Perceived Loss of Control: When robots are used to care for the elderly, the robots are responsible for their own maintenance. This is a classic case of moral hazard, when one group controls resource allocation while another bears the brunt of the benefits or costs. A decrease in the quality of social interactions with certain individuals [8] may lead to reliance and even loss of control [20].

Isolation and Psychological Risk: The possibility of robots generating feelings of isolation and less social connection has been mentioned in the literature. Because they limit human contact and autonomy, the introduction of social robots could have a negative impact on the care process. There is concern that adding robots into eldercare would result in fewer good interactions and less human contact [29]. One of the ethical issues is that personal human contact will be supplanted by robot-assisted activities. Social interactions would surely suffer if robots entirely or partially replace human jobs [8, 20]. Academic bodies have also voiced concerns, such as the risk of surveillance, the feeling of being watched or followed with inadequate data protection, the fear of being tracked, and the fear that robots would undermine capabilities and thus have negative consequences on psychological health [15, 20].

Ethics Issues, Deceit and Embarrassment: Empathetic robots give elderly individuals with long-term companionship. Mood swings, a lack of patience, or tiredness will not affect these creatures. Robot care, on the other hand, can be harsh, insensitive, and even deceitful. Based on the notion that robots' empathy is deceptive, if not nonexistent, there is growing concern that deploying robots to deceive elderly people is unethical [8, 29, 32]. Despite a fragile older person loving robot pets and maybe not discerning between live and non-living, families may assume they are enduring embarrassment and loss of dignity as a result of deception, according to Bradwell et al. [29]. (although it is also possible this tension would ease upon witnessing potential quality of life benefits).

Technical Annoyances, Cost of Acquisition, and Maintenance: Technology adoption was seen as being hampered by a lack of technical understanding [38]. The objectives of the staff and their facilitation of support are critical in promoting robot use. The exorbitant cost of most devices, which makes them unaffordable for both consumers and businesses, is a key hurdle to robotic system application. It's also unclear if health insurance or social assistance will cover these costs [20]. Other potential impediments to robotic settings mentioned in the literature include potential anxiety induced by klunky or loud noises, "not being adapted" to the intended context owing to being too large, and "failed technology" in certain areas [20, 28].

Communication Disruption among Care Personnel: Care robots may obstruct communication between nurses and patients, as well as among medical workers, restricting

the flexibility and adaptability of personalised nursing services [2]. While robots can remedy human nature's bad features, they lack the human senses of compassion, empathy, and comprehension [29].

Perceived Impact on the Nursing Career: Robots have the potential to cause undesirable behavioral changes. The rising usage of robots for elderly persons may provide incentives for health bodies to reduce or even eliminate human jobs in favor of artificial jobs, thereby altering society's character [20]. Because of concerns and reservations about the probable substitution of their occupations and positions, healthcare personnel' attitudes toward the deployment of assistive healthcare robotics are negative. Many people are concerned that robots will eventually replace humans in the workplace [39]. As a result, the fear of doctors and nurses being replaced by robots is a major impediment to deployment. While it is widely acknowledged that robotic systems are not meant to replace human interaction in health and social care [20], but rather to reduce workload [2], these issues must be addressed. The attempt to establish robot professions may lead to a drop in interest in nursing as a vocation, which will exacerbate professional shortages [8]. However, because most existing nursing robot prototypes are designed as aides rather than autonomous professions, the care resource gap will surely worsen.

4 Reflections and Critical Review

The nursing bodies (in a caregiver model) and the elderly (in self-care use cases) in the healthcare ecosystem are the social systems in our paper's environment. IS research has looked at the social-technical relationship as interactions [52], with a focus on the dynamics of interplay between the two components, such as fit, alignment, entanglement, and so on [47], as well as analyses of the issues users face as a result of potential mismatches.

Investigations have looked into how work routines and healthcare information technology (HIT) co-evolve and interact in an HIT implementation to produce or hinder the desired outcomes [33].

Other studies looked at medical assisting technology such as robotic surgery [53] and rehabilitation techniques [54, 55]. Principles for transitioning to sociotechnical ecosystems for elderly care [56], system design for disabilities [57], and user requirements for inclusive technology [58] have all been discussed in other contributions.

We discovered that the literature focused on the phenomena and its main determinants in the following areas: caring for persons with learning impairments [59], geriatric care [60], physical disability help [57], chronic care [61], and fostering better caregiver relationship [62]. The adoption of technology by the healthcare workforce is primarily dependent on the system's dependability and, as a result, their trust [28]. The elderly will become more receptive of healthcare robotics as healthcare practitioners adopt them [17]. It has become clear that the acceptance of robotics in care settings is affected by the behavior of the end users, "the elderly", and 'the caregivers" [14].

Our research has found that there is a lot of evidence that healthcare robots can help with nursing care. Our critical analysis goes a step further to explain how technological advancements may assist and risk nurses and care seekers at the same time [48]. As

we report on our findings linking the good outcome of the usage of care robots, in the form of value in use, and disadvantages in the form of unintended consequences of benefits, we reframe the conversation to demonstrate evidence of value in use (Sect. 4.1) and highlight potential drawbacks (Sect. 4.2). Technology's quick advancement and the relatively gradual advancement of concepts about how to organize and manage change may obstruct the realization of benefits (Sect. 4.2). Caring robots may be appropriate to react to and provide the illusion of care for their users, even if they are unable to deliver genuine care. As long as human care is in short supply, robots may be able to assist the vulnerable and relieve caretakers. Nurses, on the other hand, acknowledge that machines have drawbacks and that having a nurse present is advantageous to patients.

This study summarizes how disruptions in care robotics can have organizational and societal repercussions, some of which have been addressed in research studies and others, which will need time and more use to appear.

4.1 Evidence of Value in Use

Robots will have a role in nursing facilities, supporting carers and even offering company to the lonely. While different cultures have varied perspectives on the employment of robotics, the hope is that robots will make aged-care vocations less hard, more autonomous, and allow seniors to live a safer and longer independent life in their own homes. Many older people prefer to live in their familiar social setting at home rather than in residential aged care facilities that are equipped to support the health and social wellbeing of elderly people, but some are unable to do so due to family issues, illnesses, impairments, immobility, and social limitations.

Our research found that intelligent care-giving equipment, such as care robots, have the potential to enhance health outcomes by tailoring treatment for patients. Based on a patient's diagnostic profile, preferences, or treatment progress, these systems might be programmed with the knowledge and abilities of various evidence-based practices and then administer the most appropriate therapy or integrate several approaches. While their growing ability to detect, identify, and respond to the emotions and other stimuli of the patient (user) can be extremely useful in a therapeutic context, care robots can also assist professionals in providing high-quality care.

4.2 Unintended Consequences of Benefits

Human beings gain from technology advancements while also being threatened by them [48]. Although STS theory and practice have been in the background for some time, the rapid advancement of technology and the relatively slow advancement of ideas about how to organize and manage change may obstruct the realization of advantages.

The use of technology in close proximity to human function may have unintended or unforeseeable consequences. These results could mean more work for practitioners, as well as changes in communication patterns and workflows, which can lead to an overreliance on technology [42].

These unintended repercussions can be both positive and negative, with results that differ from what was originally intended (Table 2). This phenomena has been linked

to the introduction of technology in various contexts, particularly in healthcare settings [43, 44].

Our investigation discovered several instances of unforeseen repercussions of the use of a care robot in the nursing function for aged care (Table 2). The literature reveals the cost-effectiveness of care robots when assigned repetitive and banal care activities, higher satisfaction with care, and a decrease in violent events, with the possibility of including logistical or surveillance for physical safety monitoring. However, because of their machine nature, robots may necessitate costly routine maintenance and technical advancement to lessen the risk of malfunctioning annoyances [34]. Any flaws or errors.

Another example comes from the practitioner's experience, in which robots have been discovered to reduce the caretakers' burden of care in specific situations. They do so by taking over some of the more monotonous and time-consuming activities, but they must operate entirely under the supervision of a health care provider in order to maintain the "human touch" and avoid unethical practices.

Table 2. Unintended consequences of care robots – sociotechnical perspective (our review)

STS dynamics	Benefit	Unintended consequences
Organization	Essential where care workers are unavailable	Reliance on robots care hinders communication among personnel
People	Promotes personal privacy and dignity through companionship and conversation	Potential increase in feelings of isolation owing to less social interaction
	Decrease the burden of care of the caregivers	Supervision of health care provider required to prevent the unethical use
System	Cost-effectiveness of care robots repetitive/mundane care tasks	Require costly regular maintenance and technological enhancement
Task	Increased safety and reduction of violence due to monitoring	Malfunctions or lack of proper upkeep lead to accidents or injuries

Assistive healthcare robots are critical in situations where care personnel are unavailable owing to resource restrictions, a lack of training, or a lack of time to give proper care. However, in certain cases, reliance on robotic care has hampered communication among healthcare workers [5], and ethical concerns have also been noted as barriers to adoption that must be handled properly [29]. As a result, the contextual use of these robotic helpers must complement the role of coordination and care of their settings, ensuring that humans and humanoids collaborate for better care and reducing the impact of such unintended outcomes.

4.3 Value Co-creation Opportunity Involving Users in Care Robot Design

Frameworks for evaluating the role of robotics in healthcare across socio-ecological levels have been described in the literature, with specific concerns at each level as well as design, development, and implementation considerations for healthcare robots [40]. The acceptance of care robots is influenced by the attitude, ability, and skepticism of healthcare staff regarding the use of modern technology [39]. Personality traits, cognitive capacity, education, and community influence the acceptance of care robots.

Some investigations of people's views about care robots appear to show negative and unpleasant consequences. To accommodate these differing perspectives, a thorough needs assessment must be conducted, which will ensure successful implementation. Guidelines for user incorporation in ambient assisted living projects effectively summarize the importance of such evaluation: 'Determining individual user needs rather than merely guessing or generalizing can mean the difference between a true breakthrough for users and a cool technological advancement for the shelf.' This involves a thorough understanding of the requirements and wishes of older persons in terms of these gadgets.

Although previous research has primarily focused on existing robot acceptance, it is critical to understand why older people embrace or oppose assistive robots, as well as their perceptions of them, in order to improve not only the design of these robots but also to develop successful marketing strategies.

Before deployment, users should be actively involved in the development process and receive proper training and knowledge. In health and social care, diverse stakeholders with very different requirements might engage with robotic systems. It is difficult to introduce such intrusively disruptive ideas if the real results do not meet the users' expectations. Early conversations about potential roles and flaws should begin to overcome this barrier, and an iterative process should be used to include individual experiences.

4.4 Care Robots, Viable Actors in Optimizing Health System Performance

The ability of virtual humans and robots to recognize, respond to, and express emotions is being improved. Robots may also be sensitive to and adapt to features of a patient's culture, such as race/ethnicity or socioeconomic level. Intelligent care-giving devices that combine sensing, artificial intelligence, and emotive computing technologies have the potential to significantly enhance health outcomes for care recipients by tailoring their care. These systems could be programmed with knowledge and abilities from a variety of evidence-based treatments, and then offer or combine the most appropriate therapy or approaches based on a patient's diagnostic profile, preferences, or treatment progress. Intelligent care-giving machines could also be sensitive to and adapt to specific features of a patient's culture, such as race/ethnicity or socioeconomic status.

AI, robotics, and smart technologies, on the other hand, have yet to fully compete with the warmth of human presence. Basic human touch, such as shaking hands before and after a session with a patient, resting a hand on the shoulder of a grieving person, or providing a patient a tissue to wipe their tears, are still invaluable.

Care robots, on the other hand, can be viewed as viable players in improving healthcare system performance. At the service of patients and their healthcare providers, intelligent machines provide a number of benefits. Modern expert systems and other intelligent

machines can aid in the completion of highly complex tasks with greater efficiency, accuracy, and consistency. Hospital robots can complete normal rounds and are not affected by weariness, boredom, burnout, or amnesia [19]. Nonetheless, the usage of care robots serves the quadruple goal of care, health, cost, and purpose in work [41], emphasizing that patient care necessitates provider care. In this study, we apply the quadruple objective to the nursing function, where assistive care robots can help improve patient experience, population health, and work life while keeping a focus on enhancing health care providers' work lives.

5 Conclusion and Further Research Prospects

For future study, the literature review might be expanded to include more sources, such as systems thinking and robot-human interaction, while also considering future research approaches linked to the STS approach, as well as contextual and cultural elements. We do, however, make some useful recommendations for future research and translation of the quadruple aim for health improvement in the context of the nursing function, where assistive robots can help improve patient experience, population health and life, and health care personnel' work lives.

This research examines the sociotechnical aspects of robotics and their practical ramifications. Because the field of robotics is seen as part of the next prospective Kondratiev wave (together with biotechnology), greater breakthroughs in robotics are likely as humanoid innovations spark technical revolutions, resulting in leading industrial or commercial sectors. Because the potential benefits for healthcare are immense, early implementation in this field is advantageous. Finally, caregivers recognize that resistance to welfare technology adoption derives from organizational, societal, technological, and ethical problems. Individual acceptance is required for robotic systems to be adopted in real-world circumstances, according to sociotechnical principles of technology adoption. Because disruptive inventions might be difficult to accept, user participation is a key factor in determining whether or not assistive robots will be accepted.

While demand for assistive healthcare robots for the elderly and disabled is currently low, the market is expanding as robot care applications increase and become more user-friendly. The truth is that the maturity and readiness of the technology are still unknown. On the adoption front, assistive gadgets have been appreciated by older clients, health care providers, and family members, but further research into their results and efficacy is needed. Future research should look into whether these issues will endure or if new technologies can help to improve the user interface and safety perception.

User participation studies will help guide principles of usability (fit for use) and usefulness (fit for purpose) of care robots. Here too, we sense that additional research on the established environmental barriers, such as overall noise levels or spatial arrangement would be useful.

We observed some critical gaps in priority issues, notably for ethical usage of companion robots with older individuals, between the robot ethics community and real-world stakeholders, using the academic perspective of this review. It is clear that ethical and social concerns play a role in the opposition to the employment of care robots in elder care. Ethics is a delicate subject that has aroused both positive and negative responses.

As a result, we realize the necessity for ethical investigations that take into account the implications for stakeholders as well as the seeming lack of consensus on often debated problems [37]. Robotic care might be seen as heartless and unsympathetic, as well as deceitful. From an ethical standpoint, assistive healthcare robots should not be viewed as a substitute for human care, and they should be utilized under the supervision of caregivers to preserve the dignity of the elderly.

Will synthetic gestures of empathy and goodwill be perceived as similar to the genuine thing? Will science advance to the point where data and decision-making replace the requirement for human interaction? What impact would this have on mental health?

These issues require further study, as we continue to develop intelligent care machines.

References

1. Mitzner, T.L., Chen, T.L., Kemp, C.C., Rogers, W.A.: Identifying the potential for robotics to assist older adults in different living environments. Int. J. Soc. Robot. **6**(2), 213–227 (2013). https://doi.org/10.1007/s12369-013-0218-7
2. Abdi, J., Al-Hindawi, A., Ng, T., Vizcaychipi, M.P.: Scoping review on the use of socially assistive robot technology in elderly care. BMJ Open **8**, 1–20 (2018)
3. Christoforou, E.G., Panayides, A.S., Avgousti, S., Masouras, P., Pattichis, C.S.: An overview of assistive robotics and technologies for elderly care. In: Henriques, J., Neves, N., de Carvalho, P. (eds.) XV Mediterranean Conference on Medical and Biological Engineering and Computing – MEDICON 2019 **76**, 971–976 (2020)
4. Kyrarini, M., et al.: A Survey of Robots in Healthcare. Technologies **9**(8), 1–26 (2021)
5. Lee, J.-Y., et al.: Nurses' needs for care robots in integrated nursing care services. J Adv Nurs **74**, 2094–2105 (2018)
6. Broadbent, E., et al.: Using robots at home to support patients with chronic obstructive pulmonary disease: pilot randomized controlled trial. J. Med. Internet Res. **20**(2), 1–15 (2018)
7. Kim, J.: Use of robots as a creative approach in healthcare ICT. Health Informatics Research **24**(3), 155–156 (2018)
8. O'Brolcha´in, F.: Robots and people with dementia: Unintended consequences and moral hazard. Nursing Ethics **26**(4), 962–972 (2019)
9. Hosseini, S.H., Goher, K.M.: Personal care robots for older adults: an overview. Asian Social Science **13**(1), 11-19 (2017)
10. Pekkarinen, S., et al.: Embedding care robots into society and practice: socio-technical considerations. Futures **122**, 1–15 (2020)
11. Melkas, H., Hennala, L., Pekkarinen, S., Kyrki, V.: Impacts of robot implementation on care personnel and clients in elderly-care institutions. Int. J. Med. Informatics **134**, 1–6 (2020)
12. Bednar, P.M., Welch, C.: Socio-technical perspectives on smart working: Creating meaningful and sustainable systems. Information Systems Frontiers, 1–18 (2019)
13. Tuisku, O., Pekkarinen, S., Hennala, L., Melkas, H.: Robots do not replace a nurse with a beating heart: The publicity around a robotic innovation in elderly care. Information Technology and People (2018)
14. Johansson-Pajala, R.-M., Gustafsson, C.: Significant challenges when introducing care robots in Swedish elder care. Disability and Rehabilitation: Assistive Technology, 1–13 (2020)
15. Céspedes, N., et al.: A socially assistive robot for long-term cardiac rehabilitation in the real word. Front. Neurorobot. **15**(633246), 1–19 (2021)

16. Oña, E.D., Garcia-Haro, J.M., Jardón, A., Balaguer, C.: Robotics in health care: perspectives of robot-aided interventions in clinical practice for rehabilitation of upper limbs. Appl. Sci. **9**, 1–27 (2019)
17. Lukasik, S., Tobis, S., Kropinska, S., Suwalska, A.: Role of assistive robots in the care of older people: survey study among medical and nursing students. J. Med. Internet Res. **22**(8), 1–10 (2020)
18. Shishehgar, M., Kerr, D., Blake, J.: The effectiveness of various robotic technologies in assisting older adults. Health Informatics J. **25**(3), 892–918 (2019)
19. Luxton, D.D.: Recommendations for the ethical use and design of artificial intelligent care providers. Artif. Intell. Med. **62**(1), 110 (2014)
20. Servaty, R., Kersten, A., Brukamp, K., Mohler, R., Mueller, M.: Implementation of robotic devices in nursing care. Barriers and facilitators: an integrative review. BMJ Open **10**, 1-11 (2020)
21. Christoforou, E.G., Avgousti, S., Ramdani, N., Novales, C., Panayides, A.S.: The upcoming role for nursing and assistive robotics: opportunities and challenges ahead. Frontiers in Digital Health **2**(585656), 1–13 (2020)
22. Pirhonen, J., Melkas, H., Laitinen, A., Pekkarinen, S.: Could robots strengthen the sense of autonomy of older people residing in assisted living facilities?—A future-oriented study. Ethics Inf. Technol. **22**(2), 151–162 (2019). https://doi.org/10.1007/s10676-019-09524-z
23. Alaiad, A., Zhou, L.: The determinants of home healthcare robots adoption: an empirical investigation. Int. J. Med. Informatics **83**(11), 825–840 (2014)
24. Fasola, J., Mataric´, M.J.: A socially assistive robot exercise coach for the elderly. Journal of Human-Robot Interact **2**(2), 3–32 (2013)
25. Hung, L., et al.: The benefits of and barriers to using a social robot PARO in care settings: a scoping review. BMC Geriatr. **19**, 1–10 (2019)
26. Flandorfer, P.: Population ageing and socially assistive robots for elderly persons: the importance of sociodemographic factors for user acceptance. International Journal of Population Research, 1–14 (2012)
27. Birks, M., Bodak, M., Barlas, J., Harwood, J., Pether, M.: Robotic Seals as Therapeutic Tools in an Aged Care Facility: A Qualitative Study. Journal of Aging Research **2016**, 1–7 (2016)
28. Céspedes, N., Raigoso, D., Múnera, M., Cifuentes, C.A.: Long-Term Social Human-Robot Interaction for Neurorehabilitation: Robots as a Tool to Support Gait Therapy in the Pandemic. Front. Neurorobot. **15**(612034), 1–12 (2021)
29. Bradwell, H.L., Winnington, R., Thill, S., Jones, R.B.: Ethical perceptions towards real-world use of companion robots with older people and people with dementia: survey opinions among younger adults. BMC Geriatr. **20**, 1–10 (2020)
30. Hersh, M.: Overcoming barriers and increasing independence – service robots for elderly and disabled people. Int. J. Adv. Rob. Syst. **12**, 1–33 (2015)
31. Agrigoroaie, R.M., Tapus, A.: Developing a healthcare robot with personalized behaviors and social skills for the elderly. In: International Conference on Human Robot Interaction (Christchurch) (2016)
32. Wachsmuth, I.: Robots like me: challenges and ethical issues in aged care. Front. Psychol. **9**, 1–3 (2018)
33. Goh, J.M., Gao, G., Agarwal, R.: Evolving work routines: adaptive routinization of information technology in healthcare. ISR **22**(3), 565–585 (2011)
34. Pohl, M.: Robotic systems in healthcare with particular reference to innovation in the 'Fourth Industrial Revolution' — an ethical challenge for management. J. Int. Advan. Japanese Stud. **8**, 17–33 (2016)
35. Gratch, J., Wang, N., Gerten, J., Fast, E., Duffy, R.: Creating rapport with virtual agents. In: Pelachaud, C., et al. (eds.) Intelligent virtual agents, pp. 125–138. Springer: Berlin, Heidelberg (2007)

36. Picard, R.: Affective computing. MIT Press, Cambridge, MA (1997)
37. Mansouri, N., Goher, K.: Towards ethical framework for personal care robots: review and reflection. Asian Soc. Sci. **12**(10), 152–162 (2016)
38. Vichitkraivin, P., Naenna, T.: Factors of healthcare robot adoption by medical staff in Thai government hospitals. Heal. Technol. **11**(1), 139–151 (2020). https://doi.org/10.1007/s12553-020-00489-4
39. Boumans, R., Van Meulen, F., Hindriks, K., Neerincx, M., Olde Rikkert, M.G.M.: Robot for health data acquisition among older adults: a pilot randomised controlled crossover trial. BMJ Qual Saf, **28**, 793–799 (2019)
40. Mois, G., Beer, J.M.: The role of healthcare robotics in providing support to older adults: a socio-ecological perspective. Current Geriatrics Reports **9**(2), 82–89 (2020). https://doi.org/10.1007/s13670-020-00314-w
41. Bodenheimer, T., Sinsky, C.: From triple to quadruple aim: care of the patient requires care of the provider. The Annals of Family Medicine **12**(6), 573–576 (2014)
42. Tonn, B.E., Stiefel, D.: Anticipating the unanticipated-unintended consequences of scientific and technological purposive actions. World Futures Review **11**(1), 19–50 (2019)
43. Harrison, M.I., Koppel, R., Bar-Lev, S.: Unintended consequences of information technologies in health care—an interactive sociotechnical analysis. JAMIA **14**(5), 542–549 (2007)
44. Campbell, E.M., Sittig, D.F., Ash, J.S., Guappone, K.P., Dykstra, R.H.: Types of unintended consequences related to computerized provider order entry. JAMIA **13**(5), 547–556 (2006)
45. Samad-Soltani, T., Rezaei-Hachesu, P., Ghazisaeedi, M.: Pervasive decision support systems in healthcare using intelligent robots in social media. Iran. J. Public Health **46**(1), 148 (2017)
46. Scoglio, A.A., Reilly, E.D., Gorman, J.A., Drebing, C.E.: Use of social robots in mental health and well-being research: systematic review. J. Med. Internet Res. **21**(7), e13322 (2019)
47. Strong, D.M., Volkoff, O.: Understanding organization-enterprise system fit: a path to theorizing the information technology artifact. MISQ **34**(4), 731–756 (2010)
48. Pasmore, W., Winby, S., Mohrman, S.A., Vanasse, R.: Reflections: sociotechnical systems design and organization change. J. Chang. Manag. **19**(2), 67–85 (2019)
49. Krings, B.J., Weinberger, N.: Assistant without master? some conceptual implications of assistive robotics in health care. Technologies **6**(1), 13 (2018)
50. Bostrom, R.P., Heinen, J.S.: MIS problems and failures: a socio-technical perspective Part I: The causes. MIS Quarterly **1**(3), 17 (1977)
51. Read, G.J., Salmon, P.M., Lenné, M.G., Stanton, N.A.: Designing sociotechnical systems with cognitive work analysis: putting theory back into practice. Ergonomics **58**(5), 822–851 (2015)
52. Sarker, S., Chatterjee, S., Xiao, X., Elbanna, A.: The sociotechnical axis of cohesion for IS discipline: its historical legacy and its continued relevance. MIS Q. **43**, 695–719 (2019)
53. Catchpole, K., et al.: Human factors in robotic assisted surgery: lessons from studies 'in the Wild.' Appl. Ergon. **78**, 270–276 (2019)
54. Grüneberg, P.: Empowering patients in interactive unity with machines: engineering the HAL (Hybrid Assistive Limb) robotic rehabilitation system. In: Humans and Devices in Medical Contexts, pp. 255–280. Palgrave Macmillan, Singapore (2021)
55. Kendall, E., et al.: HabITec: a sociotechnical space for promoting the application of technology to rehabilitation. Societies **9**(4), 74 (2019)
56. Pekkarinen, S., Melkas, H., Hyypiä, M.: Elderly Care and Digital Services: Toward a Sustainable Sociotechnical Transition. In: Toivonen, M., Saari, E. (eds.) Human-Centered Digitalization and Services. TSS, vol. 19, pp. 259–284. Springer, Singapore (2019). https://doi.org/10.1007/978-981-13-7725-9_14
57. Blume, S., Galis, V., Pineda, A.V.: Introduction: STS and disability. Sci. Technol. Human Values **39**(1), 98–104 (2014)

58. Jovanović, M., De Angeli, A., McNeill, A., Coventry, L.: User requirements for inclusive technology for older adults. International Journal of Human–Computer Interaction, 1–19 (2021)
59. Badr, N.G., Asmar, M.K.: Meta principles of technology accessibility design for users with learning disabilities: towards inclusion of the differently enabled. In: Exploring Digital Ecosystems, pp. 195–209. Springer, Cham (2020)
60. Pekkarinen, S., Melkas, H.: Welfare state transition in the making: focus on the niche-regime interaction in finnish elderly care services. Technol. Forecast. Soc. Chang. **145**, 240–253 (2019)
61. Tan, S.Y., Taeihagh, A.: Governing the adoption of robotics and autonomous systems in long-term care in Singapore. Policy and society, 1–21 (2020)
62. Badr, N.G., Sorrentino, M., De Marco, M.: Health information technology and caregiver interaction: building healthy ecosystems. In: International Conference on Exploring Service Science, pp. 316–329. Springer, Cham (September 2018)