Adoption of Artificial Intelligence-Enabled Robots in Long-Term Care Homes by Healthcare Providers: A Scoping Review

Karen Lok Yi Wong, Lillian Hung, Joey Wong, Juyoung Park, Hadil Alfares, Yong Zhao, Abdolhossein Mousavinejad, Albin Soni, Hui Zhao

Submitted to: JMIR Aging
on: December 07, 2023

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Abstract

Background: Long-term care (LTC) homes face the challenges of increasing care needs of residents and a shortage of healthcare providers. Literature suggests that artificial intelligence (AI) enabled robots may solve such challenges and support person-centred care. Scant literature is from the perspectives of healthcare providers, even though their perspectives are crucial to implementing AI-enabled robots. This scoping review aims to explore this scant body of literature to answer two questions: (a) What barriers do healthcare providers perceive in adopting AI-enabled robots in LTC homes? and (b) What practical strategies can be taken to overcome these barriers and facilitate the adoption of AI-enabled robots in LTC homes?

Objective: This scoping review aims to explore this scant body of literature to answer two questions: (a) What barriers do healthcare providers perceive in adopting AI-enabled robots in LTC homes? and (b) What practical strategies can be taken to overcome these barriers and facilitate the adoption of AI-enabled robots in LTC homes?

Methods: We adopted the Person-Centred Practice Framework (PCPF) and Consolidated Framework for Implementation Research (CFIR) as the primary and supplementary theoretical frameworks to guide our analysis of findings. We are a team consisting of three researchers, two healthcare providers, two research trainees, and a family partner with diverse disciplines in nursing, social work, engineering, and medicine. Referring to the Joanna Briggs Institute (JBI) methodology, our team searched the databases (CINAHL, MEDLINE, PsycINFO, Web of Science, ProQuest, and Google) for peer-reviewed and gray literature.

Results: This review includes 35 articles that met the inclusion criteria. We identified three barriers to AI-enabled robot adoption: 1) Perceived technical complexity and limitation, 2) Negative impact, doubted usefulness, and ethical concerns, and 3) Resource limitations. Strategies to mitigate these barriers were also explored: a) Accommodate various needs of residents and healthcare providers, b) Increase understanding of the benefits of using robots and reassure robots can never replace humans, c) Overcome the safety issues, and d) boost interest in the use of robots and provide training.

Conclusions: Our findings closely align with three domains of the PCPF: Professionally Competent, Potential for Innovation and Risk-Taking, and Supportive Organizational Systems. The PCPF offers a useful heuristic to guide our analysis of practice innovation. To address limitations in the PCPF, we also integrated elements from the CFIR into PCPF, which provided more constructs when we considered the resource barriers. Our results underscore the necessity of including the voices of healthcare providers and other stakeholders in the research development and implementation phases for AI-enabled robots. Future research should extend this conversation by exploring diverse stakeholder perspectives.

(JMIR Preprints 07/12/2023:55257)
DOI: https://doi.org/10.2196/preprints.55257

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Results: This review includes 33 articles that met the inclusion criteria. We identified three barriers to AI-enabled robot adoption: 1) perceived technical complexity and limitation, 2) negative impact, doubted usefulness, and ethical concerns, and 3) resource limitations. Strategies to mitigate these barriers were also explored: i) accommodate various needs of residents and healthcare providers, ii) increase understanding of the benefits of using robots, iii) review and overcome the safety issues, and iv) boost interest in the use of robots and provide training.

Discussion and Conclusion: Previous literature suggested using AI-enabled robots to resolve the challenges of the increasing care needs and staff shortage in long-term care. Yet, our findings showed that healthcare providers might not use robots because of different considerations. The implication is that the voices of healthcare providers need to be included in using robots.

Keywords: artificial intelligence; robot, long-term care home, healthcare provider, scoping review, person-centred care

Introduction

Long Term Care (LTC) provides various services designed to meet the chronic health and personal care needs of those who can no longer perform daily activities independently.[1] LTC healthcare providers face challenges to meet the increased demand from older adults and their family caregivers due to a dramatically increasing aging population and growing chronic disease burden.[2] Healthcare providers in LTC homes often engage in repetitive tasks, many involving physical labour, which could lead to a high risk of job stress, physical or emotional exhaustion, burnout, and high turnover, all of which contribute to lower quality of care.[3–5] Thus, innovative solutions are required to meet LTC home residents' healthcare needs and reduce the workload for healthcare providers.

Artificial intelligence (AI) enabled robots have been perceived as a solution to the crisis in LTC homes, where significant labour shortages will accompany rapidly increasing care demand.[6–8] AI-enabled robots have been used to support person-centred care for older adults and attend to the emotional, social and physical needs of older adults. For example, PARO, a socially assistive robot, can interact with and provide emotional support for patients with dementia.[9] Physically assistive robots can perform tasks such as dressing and sit-to-stand support.[10] Evidence has suggested that using AI-enabled robots in LTC homes could optimize resources, enhance resident outcomes, create patient-centred care, satisfy residents' needs, and improve healthcare providers' workflow.[2] While AI-enabled robots may potentially alleviate the burden on healthcare workers and enhance efficiency in LTC homes, they also pose risks. Issues associated with AI-enabled robot use were explored in the literature. In LTC homes, the adoption and use of robotics are associated with ethical issues and technological risks such as safety, privacy and data security, liability, and effects on the incumbent workforce.[11] Accordingly, research has been focusing on examining attitudes and perceptions of AI-enabled robots. [12]

Recent AI-enabled robot studies evaluate the acceptance of this technology in elder users, including in the settings of care facilities, as well as private homes and living-lab contexts [13–18]. Findings of the literature show that older adults are generally open to robot assistants while robots provide social interactions, cognitive stimulation, home-based tasks, personal care, and information management [19,20]. However, very few studies have been focused on measuring the healthcare providers' perception of AI use, even though their acceptance of AI-enabled robots is crucial to future research and development and the implementation of AI-enabled robots in LTC homes [21]. Some studies have shown that about 40% of technologies, such as home healthcare robots and information systems, have been abandoned in the last two decades [22,23]. Several barriers to healthcare providers' adoption of AI-enabled robots were explored, including clinicians' inadequate knowledge [24] and lack of understanding of the socio-technical aspects of the technology [24]. These barriers lead to a fear of job loss among healthcare staff who worry that they will be replaced by robots for repetitive or manual tasks, even when robots are intended to assist rather than replace workers. [21,24] Therefore, understanding the perspectives of healthcare providers on AI-enabled robot use is crucial, as they can offer the most pertinent insights into risks and impacts, as well as to understand users' needs and expectations. [25]

This scoping review aims to synthesize and analyze the existing literature on potential barriers and strategies to overcome these barriers by adopting AI-enabled robots in LTC homes from the perspectives of healthcare providers. Two research questions guided the review: a) What barriers do healthcare providers perceive in adopting AI-enabled robots in LTC homes? and b) What strategies can be taken to overcome these barriers to the adoption of AI-enabled robots in LTC homes?

To our knowledge, no scoping review has been conducted on this review topic. Existing scoping reviews focus on using AI in eldercare or healthcare, such as promoting shared healthcare decision-making,[26] monitoring diabetes-related parameters,[27] and facilitating digital healthcare interventions.[28] However, these settings are not LTC homes. There are also scoping reviews on LTC homes, such as making decisions about moving into LTC homes [29] and physical rehabilitation in LTC homes.[30] Yet, they are not related to the use of technology. There are scoping reviews about technologies in LTC homes, such as using e-health to support assessment and decision-making with residents living with dementia in LTC homes [31] and defining the concepts of smart nursing homes and technology-assisted LTC homes.[32] Nevertheless, these reviews are not specifically about AI. Lukkien et al.[33] conducted a scoping review about responsible AI, that is, using AI ethically in LTC homes. Yet, the review is from the perspectives of researchers, not healthcare providers.

The paper addresses the critical gap concerning LTC healthcare provider perspectives in adopting AI robots. Staff perspectives are essential as they directly impact the acceptance, utilization, and effectiveness of AI technologies in care settings. Our findings highlight the importance of an inclusive approach to engaging LTC staff in robot development and implementation. The practical insights and strategies can empower staff to support the integration of AI technologies in LTC.

To begin with, we will define some terms used in this paper. We published a protocol for this scoping review and will refer to the definition of robot, AI, and AI-enabled robot in the protocol. [34]

(p2) “*Robots* are mechanical devices that can be of various physical forms and are designed to perform a wide range of tasks … *AI* is known as ‘the science of making [a] machine or computer to act intelligently’ [35] (p3) … The *AI-enabled robot*, or intelligence robot, can be defined as ‘a physically situated intelligent agent in the ‘real world’, regardless of shape, that can sense and act on its operational environment’ [35] (p15). AI allows robots to (a) present the world symbolically in a way that can be easily understood by computers, (b) understand natural language and explore clear communication required for comfortable social interaction between humans and robots, (c) learn by self-iterative trials and apply that learning to a range of functions, (d) plan and solve problems, (e) generate an answer without complete information, (f) use search algorithms to generate solutions in navigation or search for optimal knowledge representation and (g) improve robotic actions with vision systems in the robots.” *Healthcare providers* refer to paid staff caring for LTC home residents (e.g., nurses, care aides, and allied health professionals). LTC refers to “care settings that provide 24-hour personal care support for people with complex needs who are unable to remain at home.” [34] (p3)

Theoretical Frameworks

In this scoping review, the Person-centred Practice Framework (PCPF) [36] and Consolidated Framework for Implementation Research (CFIR) [37] are the supplementary theoretical frameworks that guided our synthesis and analysis of results to explore the barriers and strategies to overcome these barriers to the adoption of AI-enabled robots in LTC homes.

Person-centred Practice Framework (PCPF)

McCormack and McCance [38] coined the Person-centred Practice Framework (PCPF). Person-centred care is a care philosophy with people living with dementia [39]: Despite cognitive impairment, person-centred care recognizes that a person living with dementia still has personhood, should be seen as a person, and has diverse needs, such as psychosocial needs, which need to be met by care to achieve the person's holistic well-being. PCPF provides a framework for understanding the factors influencing the practice of person-centred care with people living with dementia [38,40]. Our review is about adopting AI-enabled robots to care for people with dementia. PCPF is, therefore, a good fit for our review. PCPF initially focuses on nursing practice with people living with dementia [38]. However, gradually, it has been adopted by other disciplines, such as social work [41] and rehabilitation [39]. PCPF is an evolving framework since its first publication in 2001 – Its author continues to enhance it over the years by absorbing lessons from new research and practice [36,38,40]. We adopt the latest version of PCPF from the authors’ publication in 2023 [36].

PCPF comprises five domains: prerequisite, practice environment, person-centred process, outcome, and macro context. Figure 1 presents the framework from the authors’ recent publication in 2023. [36] (p2)

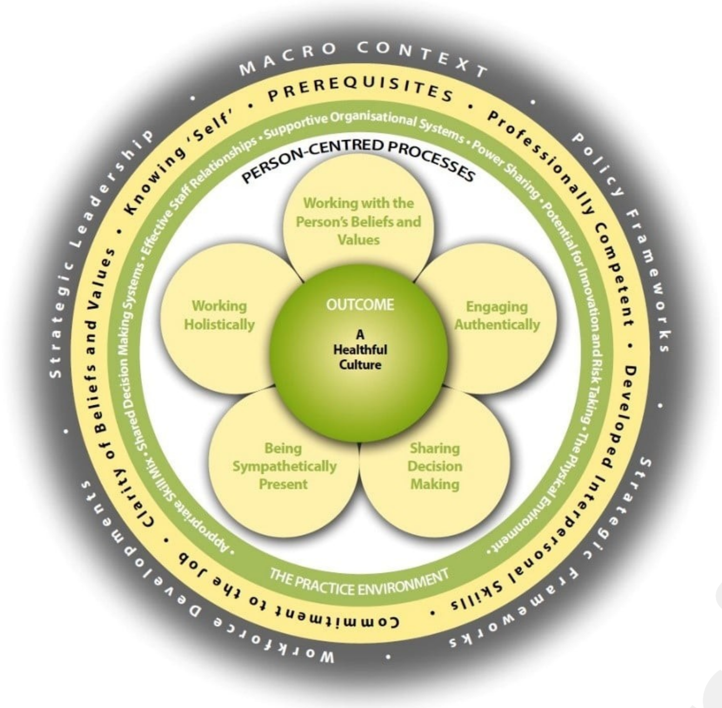


Figure 1: McCance, T., & McCormack, B. (2023). Developing healthful cultures through the development of person-centred practice. *International Journal of Orthopaedic and Trauma Nursing*, *51*, 101055. https://doi.org/10.1016/j.ijotn.2023.101055 (p2)

PCPF considers that person-centred care practice is shaped not only by factors at the level of the patient and the healthcare provider but also by factors at the level of organization and society. These domains are interrelated with each other, as elaborated by the authors [36] (p3), "to reach the centre of the framework, one must first take account of the *macro context*, followed by consideration of the attributes of staff, as a *prerequisite* to managing the *practice environment*, and in order to engage effectively through the *person-centred processes*. This ordering ultimately leads to the achievement of the *outcome*." Under each of the five domains, there are constructs. There is no hierarchy among the constructs; constructs in the same domain can be related or even overlap. [36]

The **prerequisite** domain examines the "attributes" of healthcare providers required to provide person-centred care, and the constructs under this domain are "being professionally competent, having developed interpersonal skills, being committed to the job, being able to demonstrate clarity of beliefs and values, and knowing self." [36] (p4) The **practice environment** domain looks into "the context", that is, the care setting and organization, where person-centred care is provided, and under this domain, the constructs include "appropriate skill mix; systems that facilitate shared decision making; the sharing of power; effective staff relationships; organisational systems that are supportive; potential for innovation and risk taking; and the physical environment." [36] (p4) The **person-centred process** domain explores healthcare providers' "ways of engaging that are necessary to create connections between persons (living with dementia)," and the constructs under this domain include "working with the person 's beliefs and values; engaging authentically; being sympathetically present; sharing decision making; and working holistically." [36] (p4) The **outcome domain** looks into the "result of effective person-centred practice," and the authors suggest that effective person-centred practice should "enable human flourishing for those who give care and for those who receive care." [36] (p4) Under this domain, the constructs are that "decision-making is shared, relationships are collaborative, leadership is transformational, and innovative practices are supported.” [36] (p4) The **macro context** domain refers to regional, national, and international “factors that are strategic and political in nature that influence the development of person-centred cultures.” [36] (p3) The constructs under this domain include “policy frameworks, strategic frameworks, workforce developments, and strategic leadership.” [36] (p4)

Consolidated Framework for Implementation Research (CFIR)

Damschroder et al. [42] developed the Consolidated Framework for Implementation Research (CFIR) by consolidating constructs from 19 implementation frameworks or theories in 2009. The authors updated it by incorporating new literature and feedback in 2022 [43,44]. The latest version of CFIR is freely accessible on the CFIR website, which our review will refer to. [45] CFIR is a framework for understanding the contextual factors that influence implementation in a clinical setting/organization [44]. Our review concerns the implementation of AI-enabled robots in long-term care. Thus, CFIR and our review are a good match. In addition, previous literature suggested that CFIR can be used with other frameworks. [44] In our review, we are using it with PCPF.

According to the authors, one way to use CFIR is to better understand the findings on implementation. [44] We will use CFIR to understand the findings from the literature on healthcare providers’ perspectives on barriers to implementing AI-enabled robots and strategies for overcoming them. The authors suggested two approaches to using CFIR to understand the findings on implementation: deductive and inductive. Our study will use a mixed approach, which will be further elaborated.

CFIR comprises five domains: innovation, inner setting, outer setting, individual, and implementation process; there are constructs under each domain. and CFIR has 48 constructs [37]. The *innovation domain* explores “the “thing” being implemented,” such as research, programs, policies, and innovations. [37] The constructs under this domain include “innovation source, innovation evidence-base, innovation relative advantage, innovation adaptability, innovation trialability, innovation complexity, innovation design, and innovation cost.” [37] The *outer setting domain* examines “the setting in which the inner setting exists,” such as the health and community organizations. [37] Under this domain, the constructs are “critical incidents, local attitudes, local conditions, partnerships and connections, policies and laws, financing, and external pressure.” [37] The *inner setting domain* looks into “the setting in which the innovation is implemented,“ such as an LTC home or a hospital. [37] The constructs under this domain are “structural characteristics, relational connections, communications, culture, tension for change, compatibility, relative priority, incentive systems, mission alignment, available resources, and access to knowledge and information.” [37] The *individuals domain* explores “the roles and characteristics of individuals” involved in implementation. [37] Under this domain, the constructs include “high-level leaders, mid-level leaders, opinion leaders, implementation facilitators, implementation leads, implementation team members, other implementation support, innovation deliverers, and innovation recipients.” [37] The *implementation process domain* examines “the activities and strategies used to implement the innovation.” [37] The constructs under this domain are “teaming, assessing needs, assessing context, planning, tailoring strategies, engaging, doing, reflecting and evaluating, and adapting.” [37]

Methods

Scoping reviews are pivotal for identifying and summarizing evidence in emergent fields and highlighting significant themes, contexts, and research gaps.[46] Given the nascent stage of AI-enabled robots in long-term care (LTC) homes, a scoping review was apt for our study. Our interdisciplinary review team was comprised of three researchers, two healthcare providers, two research trainees, and an older adult partner. We each brought different expertise: Researchers and research trainees brought research knowledge and skills. Healthcare providers brought frontline experiences. The older adult partner brought in lived expertise. We came from diverse backgrounds, too: nursing, social work, engineering, and medicine. Diverse expertise and backgrounds enriched our team discussions, especially during data analysis. We followed the guidelines on scoping reviews the Joanna Briggs Institute (JBI) set out.[47] We published the objectives, inclusion criteria, and methods of this scoping review in a protocol.[34] We conducted the scoping review over six months. As data are synthesized solely from existing literature, ethics approval was not required for this scoping review.

Search Strategy

We followed a three-step search approach suggested by JBI: (a) a preliminary search using two databases (MEDLINE and CINAHL) to identify keywords and index terms, (b) using keywords and index terms from the previous step to search selected databases (CINAHL, MEDLINE, PsycINFO, Web of Science, ProQuest, and Google), and (c) hand searching of reference lists of selected items.

The participants, context, and concept of our scoping review were as follows: Participants were healthcare providers working with older adults in LTC. The context was LTC. The concept was AI-enabled robots. The search string was based on these participants, context, and concept, i.e., "healthcare provider AND older adult AND LTC AND AI." Our search limits were that we searched items published in the last ten years (2013-2023) and only included publications in English.

Item Selection

We used an online software platform, Covidence, to assist us in conducting the scoping review. Initially, we identified 279 items and uploaded them to Covidence. Subsequently, we performed two screening levels according to inclusion and exclusion criteria (see Table 1).

Table 1. Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
Includes healthcare providers in LTC homes working with older adults	Does not include healthcare providers working with older adults
Includes AI-enabled robots	Does not include AI-enabled robots
Includes LTC home setting	Acute care or community settings other than LTC home (e.g., home care, senior centers, adult day health care programs)
Published in English	In language other than English
All study designs (e.g., qualitative, quantitative, mixed methods)	
All sources (e.g., peer-reviewed journal articles, books and book chapters, conference proceedings, reports, theses, dissertations)	
Include data that addresses the two objectives of our paper	Do not include data that addresses the two objectives of our paper

We took an inclusive approach to how we considered a robot an AI-enabled robot: We considered a robot an AI-enabled robot if it has AI features according to our AI-enabled robot definition as mentioned above. Table 2 explains how each robot included in this scoping review is related to our AI-enabled definition.

Table 2: How robots are related to AI by definition

Robot Name	How it is related to AI by definition
Stevie [48,49]	Stevie is a social robot designed to be used in care settings for older adults. The robot incorporates AI to enhance its functionality and communication abilities. Like other AI-enabled robots, Stevie II can autonomously map and navigate 3D environments in real-time. Unlike other robots, Stevie uses AI to support its enhanced communication functionality. Through the use of human-like speech, gestures, and facial expressions, the robot is able to engage in clear communication required for social interaction. Furthermore, the robot leverages AI to perform various tasks such as setting reminders, entertaining older adults, and problem-solving.
Paro [50]	PARO is a seal shaped interactive robot that incorporates sensory receptors to interface with its environment. The robot is used in a variety of healthcare environments to reduce stress anxiety, improve socialization, and more by replicating the effects of animal therapy. PARO can be held, spoken to, and stroked as if it were an actual animal. AI enables PARO to remember users' actions and learn to adapt its behavior accordingly. Actions that result in positive user feedback will be repeated, while actions resulting in negative user feedback will not.
NAO [51]	NAO is a bipedal interactive humanoid robot designed for various applications, including education and research. The robot supports open-source functionality, allowing users to curate the robot to their specific needs. NAO uses AI at the lowest level to perceive the surrounding environment, understand and respond to human emotion, solve tasks, navigate using advanced vision systems, and more.
Pepper [52]	Pepper is a humanoid robot designed for social interaction and customer service. Leveraging its ability to recognize faces and human emotions, Pepper is available in businesses and schools as a helpful assistant. The robot uses AI to map and navigate its environment and solve tasks, among many other things. Above all, Pepper uses AI to recognize and respond to human emotions, making it capable of human-like communication. It also learns from interactions, allowing it to adapt and improve its responses over time.
SCITOS [53]	The SCITOS is an autonomous robot designed to be used in various applications such as research and many customer service positions. The robot is designed to interact with people through its voice, head movements, and touch display, as well as guide people in various settings. It uses AI to map and navigate its environment, avoiding obstacles and identifying its position in a 3d space. AI is also used for effective communication, equipping SCITOS with the ability to interact with and understand humans. This AI-enabled emotional recognition allows the robot to guide visitors, provide explanations, and play fun games such as hide and seek.
Tangy [54]	Tangy is a social robot designed to assist with social and interactive tasks. The main use case for Tangy is as a bingo assistant in long-term care settings. Using AI, Tangy can autonomously support elder adults in playing bingo. The robot is able to call bingo numbers, help individuals, ensure the accuracy of winning bingo cards, and congratulate winners.

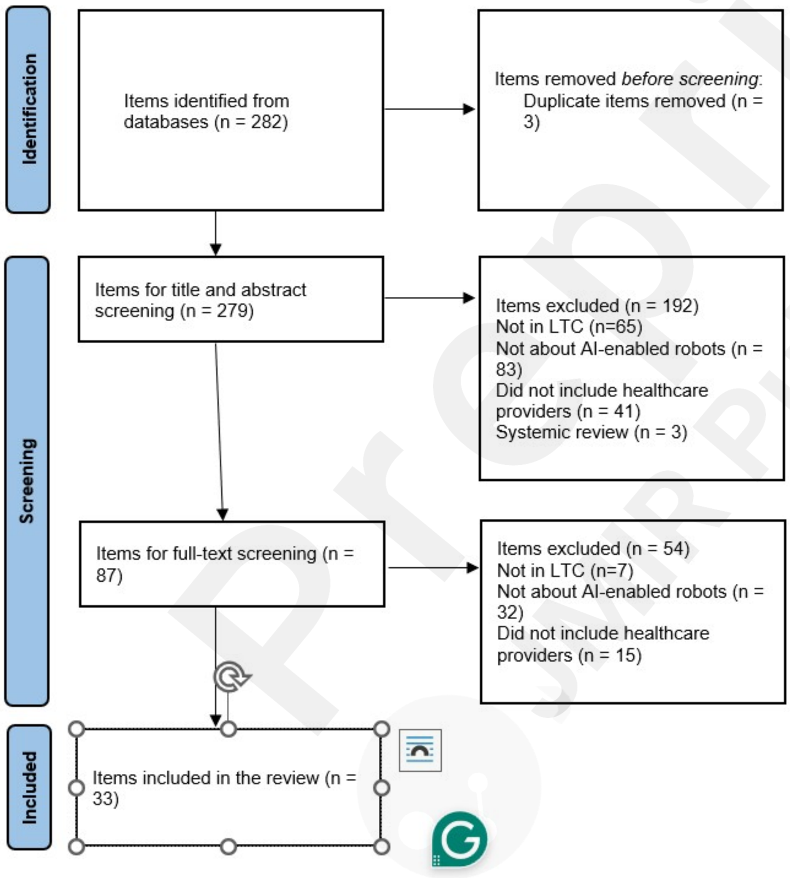
	These functionalities are supported by AI, which enables Tangy to perceive and influence its surrounding environment. AI also allows the robot to recognize certain bingo cards as winners, an ability made possible with improved computer vision systems. Tangy also uses AI to integrate information from different sensors, which allows it to identify and communicate when certain bingo numbers are called.
MARIO [55,56]	The MARIO robot is a social robot that builds on existing Kompai architecture with the purpose of providing companionship and support. The robot is intended for use with individuals who have dementia in long-term care settings. The robot applies AI at various levels to supplement its predetermined functionalities. Simultaneous mapping and navigation are possible through the AI-driven integration of sensor data, although this requires more constant environments. It's also able to understand and respond to human communication, which allows it to effectively engage with residents. The robot supports various applications, including fall/hazard detection, which are facilitated by AI.
Roomba [57]	The Roomba is a robotic vacuum cleaner designed to automate the floor cleaning process. There are several iterations of the device that support different types of cleaning and more efficient automation. At the lowest level, the Roomba uses AI to perceive and influence its surrounding environment. Advanced sensor and mapping technology is leveraged to create a computer readable rendition of a 3D space, enabling systematic and efficient cleaning patterns.
TUG [58]	The TUG autonomous mobile robot is made specifically to deliver linens, medications, and meals in hospital settings. The robot functions to maintain order in the hospital and reduce the physical workload staff are required to manage. The TUG robot uses AI to enhance its computer vision capabilities, allowing it to map and navigate 3D environments and make use of existing navigation infrastructures (e.g. elevator). The AI-enabled robot also can identify hazards in real-time, which is integral in healthcare settings that may contain patients, caregivers, and other individuals.
PaPeRo [59]	PaPeRo is a social robot being developed to appeal to various populations, with the intention of providing companionship. The robot uses AI to engage in human conversation, recognizing over 200 words and speaking in a natural voice. The robot can also perceive the volume of sounds in the environment and adjust its behavior accordingly. Furthermore, the robot makes use of image recognition technology to identify faces. While not actively engaging with individuals, the robot makes use of AI to map and traverse through its environment while dancing and singing on its own. PaPeRo is also able to identify hazards in its environment.
Temi [60]	Temi is a social robot designed for home and business applications. The robot acts as an autonomous personal assistant following users, saving locations, setting tasks, and providing facetime functionalities. Temi uses AI to map and navigate its environment, facilitating autonomous motion. The robot can also identify environmental hazards and adapt to its travel to suit different types of surfaces (wood, carpet, etc). It can also understand and respond to voice commands, demonstrating an ability to

	engage in human-like communication while also learning and adapting to users' behaviors over time.
Grace [61]	Grace is an advanced humanoid robot designed for healthcare applications. The robot emulates healthcare professionals with a human-like appearance and its ability to interact with patients, record key vitals (temperature, responsiveness), engage in therapeutic conversation, and help other healthcare professionals. AI is deeply embedded into almost all components of Grace, allowing for autonomous movement, diagnosing of some conditions, and most of all, human-like communication. The robot uses AI in conjunction with electrical components to replicate facial expressions, which facilitate its ability to communicate and provide companionship. The robot is mainly used to provide social stimulation to older adults and others isolated in healthcare settings.
PR2 [62]	PR2 is a service robot that supports a wide array of use cases and can be adapted to fit different environments. PR2 robots have the dexterity to fold towels, grab drinks, pickup various items, and even make purchases in stores. The robot relies heavily on AI to perform these tasks. A variety of sensors are integrated through AI tools to create 3D representations of environments, allowing for real time mapping and navigation. The robot also supports complex problem-solving skills that allow it to adapt to complete many different tasks. AI also enables the robot to interact with humans through voice and gesture recognition.
Sota [63]	Sota is a social robot optimized for social interaction and communication. Sota is designed to give PowerPoint presentations, making use of its versatile communication skills. The robot has a unique communication style, making use of its tone of voice, arm gestures, expressions, body language, and other sounds to convey certain emotions. Sota uses AI to integrate its different skills in a coherent way suitable for presentations. For example, the 3D environment is mapped in real time which allows Sota to move around while speaking and point to key features in the presentation. Sota’s voice and gestures are all decided on using AI algorithms that can learn and adapt to audience reactions over time.
Smart Walker [64]	The Smart Walker is an AI-assistive device that is intended to aid individuals with mobility challenges. The robot can precisely detect users' movements and adjust its own behavior accordingly by moving forward, stopping, or adjusting its speed. AI allows the robot to map and navigate its environment while also detecting hazards in real time. The hazard detection functionality uses AI to detect objects in the path of the user and stop the walker, preventing collisions. Furthermore, the robot also supports gait detection and health monitoring, a feature enabled by the integration of various sensor data through AI.
AILA [65]	AILA (Artificial Intelligence Lightweight Android) is an autonomous robot designed as a research platform for autonomous mobile dual-arm manipulation. The robot can understand and navigate its environment in real-time, a feature facilitated by integrating AI technologies with various sensor modalities. Moreover, AI enables AILA to recognize specific objects in its environment through feature matching and 3D pose estimation. Based on this information, AILA can autonomously adjust its

	arms and determine the best orientation to grasp different objects. Furthermore, AILA can employ different strategies to lift and relocate objects depending on their characteristics (fragile, soft, hard).

In the first screening level, two research trainees of our team independently screened titles and abstracts of the 279 identified items. We removed 192 items, and 87 items remained. We removed 192 items because they were not conducted in LTC homes, were not about AI-enabled robots, did not include healthcare providers, or were systemic reviews. In the second screening level, the two research trainees independently reviewed the full text of the 87 selected items. We removed 54 items, and 33 items remained. The reasons for removing the 54 items were the same as those in the first screening level. We used the Preferred Reporting of Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement [66] to record the selection process (see Figure 2). When the two research trainees did not agree with each other, the researcher (LH) would decide.

Figure 2. PRISMA Chart



Data Extraction and Analysis

We extracted data from the chosen items by domain and documented the data extracted in the Data Extraction Table (see Appendix 1 attached at the end of this manuscript). The domain included “author, year, and place” of the literature, “literature type and study design/method,” “setting, population and sample size (if mentioned)” of the study, “type of AI-enabled robot and use of the robot” mentioned in the literature, “barriers to the use of the AI-enabled robot (from healthcare providers” perspectives),” and “strategies to overcome the barriers.” The data extraction tool was an enhanced version compared with the one we published in the protocol: Most of the categories of the tool in the enhanced version were similar to the protocol version. The main difference was that we removed the category on “results and implications” and added a category on “the type of AI-enabled robot and use of the robot. We initially had a category on “results and implications,” just in case we needed additional information to help us address the review questions. However, after we started data extraction, we realized that the category on “results and implications” did not provide additional information to help us address the review questions and might even divert our attention away from addressing the review questions. Therefore, after discussion, we removed this category. In opposition, when we were doing data extraction, we found that the differences in the types and uses of AI-enabled robots might relate to the review questions on barriers and strategies to overcome them. Therefore, after discussion, we added this category.

Each team member was randomly assigned items to do data extraction. Since our older adult partner expressed that he would like to help with data extraction but was less familiar with doing academic work, he was assigned fewer items (three items) than other members. We met to discuss challenges we encountered during the data extraction process and resolve them together under the guidance of the researcher (LH), experienced in the scoping review. For items that include both healthcare provider participants and non-healthcare provider participants (e.g., residents and families), we only extracted data on barriers and strategies to overcome these barriers from the perspectives of healthcare providers. For items which include AI-enabled and non-AI-enabled robots, we only extracted data on AI-enabled robots.

After data extraction, a research trainee of our team did a preliminary thematic analysis of the extracted data using NVivo 12, a qualitative data analysis software.[67] She coded the data and grouped similar codes into categories and grouped similar categories into themes. She then presented the findings to the team. The team members gave inputs to refine the findings. Through team analysis, we finalized the findings. When differing opinions on the themes arose, we reached a consensus through discussion. Team members then compared the findings with PCPF and CFIR to see how the frameworks further our understanding of the findings. We followed a mixed inductive and deductive approach in data analysis: The research trainees coded the data, and the team developed the themes inductively. However, we also compared the findings with PCPF and CFIR to further our understanding of the findings deductively.

Results

In our review, we include 33 studies conducted in 16 different countries. Most studies were from Canada and Australia. Four items (12.1%) were found in each country respectively. Three items (9.1%) are found in Austria, Japan and the United States, respectively. Among the remaining countries, either one (3.0%) (China, the Netherlands, New Zealand, Turkey and the United Kingdom) or two items (6.1%) (Finland, Germany, Switzerland and Taiwan) are found. One item (3.0%) involves more than one country (Italy, Ireland, United Kingdom). Most items were journal articles. 20 items (60.6%) fell under this category. Eight items (24.2%) were conference proceedings and three (9.1%) were book chapters. There was one (3.0%) online news article and one (3.0%) dissertation. The most researched robot among the items was the social robot Paro. 11 items (33.3%) were found mentioning Paro. Five items (15.2%) and four items (12.1%) were found mentioning humanoid robots NAO and Pepper, respectively. Two items (6.0%) were found mentioning the following robots: SCITOS, Sota and Tangy. One item (3.0%) was found mentioning the remaining robots.

Barriers to the Use of AI-enabled Robots

One of our primary research questions is to explore the barriers healthcare providers perceive in adopting AI-enabled robots in LTC homes. After reviewing and analyzing the existing literature, three barriers related to this regard were identified (See Table 3 for a summary).

Table 3. A Summary of Barriers to the Use of AI-enabled Robots

Perceived Technical Complexity and Limitation	- Perceived using AI-enabled robots complex or troublesome - Reported not having the knowledge and skills to use the robots
Negative Impact, Doubted Usefulness, and Ethical Concerns	- Worried about the AI-enabled robots' negative impacts on residents - Worried about the AI-enabled robots' negative impacts on staff
	- Doubted residents' interests in the AI-enabled robots - Doubted the usefulness of the AI-enabled robots to residents - Doubted that the robots would fit the LTC home context
	- Worried about the potential ethical issues of using AI-enabled robots - Raised ethical concerns on privacy
Resource Limitations	- Lack of human and time resources - Not enough robots - Lacked infrastructures - Worried about maintenance costs

1) Perceived Technical Complexity and Limitation

Healthcare providers perceived the technical complexity and limitations of robots as a barrier to adopting the robot. For example, in the study by Huisman and Kort[68] using the humanoid robot NAO to entertain residents and stimulate them to do physical exercises, healthcare providers expressed frustration with the complex robot's operation steps and the short robot's battery. In the study by Hebesberger et al.,[69] The autonomous robot SCITOS was used to perform safety checks around the LTC home (e.g., checking if doors were closed and fire extinguishers were in place) and greet visitors at the LTC home's lobby. Nevertheless, healthcare providers reported that the robot's slow response and rigid system discouraged their use of it. In Pfadenhauer and Dukat's study[70] on the social robot PARO, healthcare providers mentioned that as the robot could not move independently, they had to carry it around the LTC home for residents' use, which was inconvenient.

Additionally, a lack of knowledge and skills contributes to the reluctance to adopt these technologies. For example, in the study by Papadopoulos et al.[71] using the humanoid robot Pepper to interact with residents socially, healthcare providers reported not being fully equipped to operate and maintain the robot. In the study by Melka et al. [72] using the humanoid robot NAO for rehabilitation and recreational assistance, healthcare providers hesitated to use the robot as they feared making mistakes because of a lack of knowledge and skills using it. Even if there is training, the willingness to participate is low due to existing heavy workloads. For instance, referring to the study by Li et al.[73] Using humanoid robots Pepper and NAO to entertain residents, healthcare providers expressed concerns about the time needed to join training as they already had heavy workloads.

2) Negative Impact, Doubted Usefulness, and Ethical Concerns

Healthcare providers have expressed concerns, including potential negative impacts, doubts about their usefulness, and ethical implications.

Potential Negative Impacts

Some healthcare providers are concerned that AI-enabled robots might negatively impact residents. For example, one of the robots used in the ethnographic study by Chang and Šabanović [74] was the robotic vacuum Roomba, and healthcare providers expressed concerns about residents' fall risks. In the study by McGinn et al.[49] Using the social robot Stevie to communicate with residents, healthcare providers are worried about hygiene hazards, such as the robot not being adequately sterilized after use and germs spreading among residents through it. The study by Obayashi et al. [75] used the social robot Sota. Healthcare providers were concerned that the robot's flashing eyes might scare residents.

Some healthcare providers were concerned that AI-enabled robots might negatively impact them. For example, in the study by Hung et al. [11] on the use of robots, including social robot PARO, in LTC, healthcare providers expressed their concerns that using these robots increased their workloads, such as teaching and assisting residents to use the robots, cleaning and charging the robots, and handling technical glitches. The study by Mitzner et al.[76] used service robot PR2 to assist in caregiving tasks such as medication dispensing and transferring residents. Healthcare providers were concerned that the robot would replace human functions. In the study by Melkas et al.[72] using the humanoid robot NAO to assist in rehabilitation and recreation, healthcare providers were reluctant to use it as they had established workflows, and including the robot would interrupt how they had been doing things. Erebak and Turgut [77] studied healthcare providers' attitudes toward robots, such as the autonomous robot AILA. They found that healthcare providers did not trust robots to be fully autonomous in decision-making. Instead, they preferred robots that allow them to make certain decisions as humans (even though the authors did not specify what these decisions would be).

Doubted Usefulness

Some healthcare providers have raised doubts about the usefulness of AI-enabled robots for residents in LTC homes. Some providers doubted residents would be interested in robots. For example, in the study by Robinson et al.[78] on social robotic pet PARO as a companion with residents, healthcare providers raised doubts that residents would be interested in it because residents preferred real pets, and PARO looked like a toy. In the study by Louie et al.[79] using the social robot Tangy, healthcare providers said residents preferred humans, and Tangy's appearance and voice were too mechanical. In the study by Huismand and Kort[68] using the humanoid robot NAO, healthcare providers said that residents would be bored by the lack of choices of programs the robots could offer for recreation and physical exercise.

Other healthcare providers doubted the practicality of AI-enabled robots for residents. For instance, in the study by Louie et al. [79], the primary function of the social robot Tangy was to speak to residents and interact with them. However, Tangy could not speak the languages of some residents. Some healthcare providers pointed out that these residents could not understand and interact with Tangy. The study by Back et al.[80] used humanoid robot NAO to demonstrate physical exercise to residents. However, healthcare providers hesitated to use the robot because its size was too small for residents with eyesight impairment to see it, its voice was too soft for residents with hard of hearing to hear its instructions, and residents with cognitive impairment could not follow its demonstration.

Further, providers doubted that the robots would fit the LTC home context. For instance, one robot used in the study by Chang and Šabanović,[74] was the autonomous mobile robot, TUG, which was designed to help healthcare providers deliver care and medical supplies and clean the LTC home. However, healthcare providers did not find it helpful because its size was too large to navigate the LTC home’s narrow hallways.

Potential Ethical Issues

Healthcare providers have expressed ethical concerns about using AI-enabled robots in LTC settings. For example, in the study by Moyle et al. [81], social robot PARO was used to interact with residents. Healthcare providers raised concerns that the use might infantilize residents due to the robot’s toy-like appearance. In the study by Lehman et al. [82], PARO was used as a robotic pet for companionship with residents. Healthcare providers expressed concerns that the robot could deceive residents with cognitive impairment as a real pet.

Privacy concerns have also been raised, particularly concerning surveillance. For instance, Christoforou et al. [83] looked into different types of nursing and social and physical assistive robots. Some healthcare providers expressed feeling that the robots were monitoring their work. In the study by Papadopoulos et al.[71] using the humanoid robot Pepper to communicate with residents, healthcare providers worried about residents' privacy, especially since Pepper had cameras on its forehead.

3) Resource Limitations

The last barrier expressed by healthcare providers is that LTC homes lack the resources to use AI-enabled robots. The types of resources that LTC homes lack include time, robots, infrastructure, and maintenance costs. First, as suggested, healthcare providers expressed concerns about the lack of time to learn, maintain, and assist residents using the robots.[11] Second, some healthcare providers said that their LTC homes did not have enough robots. In the study by Hung et al. [11], a nurse recalled how two residents fought with each other for one social robot PARO. Third, some healthcare providers mentioned that their LTC homes lacked infrastructure for robot use. In the study by Melkas et al.[72] used a humanoid robot NAO for diverse purposes (e.g., rehabilitation and recreation), and NAO needed Wi-Fi. However, some healthcare providers mentioned that their LTC home had poor Internet connections. They also added that their LTC home did not have enough physical space to store the robot. Finally, keeping a robot is expensive, and some healthcare providers are worried about the maintenance costs. In the study by Casey et al.[84] using the social robot MARIO to stimulate residents’ cognition and memories, such as giving them updates on the news; healthcare providers were concerned about the costs of keeping the robot and suggested that it would be a better idea to spend money hiring more healthcare providers than keeping the robot.

Strategies to Overcome Barriers to the Use of AI-enabled Robots

To overcome the barriers, another primary question of our review is to identify the strategies suggested in the literature, including a) **A**ccommodate various needs of residents and healthcare providers, b) **I**ncrease understanding of the benefits of using robots, c) **R**eview and **o**vercome the safety issues, and d) **Bo**ost interests in the use of robots and provide **T**raining. The strategies can be summarized in an acronym **AI-ROBOT** (See Table 4).

Table 4. Summary of the Strategies to Overcome Barriers

		An illustrative example from literature
A	**A**ccommodate various needs of residents and healthcare providers	- Incorporate songs in languages other than English to meet the language needs of residents [85]

I	**I**ncrease understanding of the benefits of using robots	- Healthcare staff found that the robot could enhance residents' emotional well-being and bring them joy. [68]
R **O**	**R**eview and **o**vercome the safety issues with staff	- Incorporate safety designs suggested by staff into robots [89]
B **O**	**Bo**ost interests in the use of robots	- Dress up the robots to make them more attractive [91]
T	Provide **t**raining and involve staff in the planning and implementation	- Set up a Helpdesk for healthcare staff to contact by phone or email when they encounter any challenge using the robot [68]

a) Accommodate Various Needs of Residents and Healthcare Providers

One strategy is to collect feedback from healthcare providers to design AI-enabled robots that better accommodate the various needs of residents and healthcare providers. For example, one of the robots used in the study by Yuan et al.[85] was the humanoid robot NAO for communication with residents. Healthcare providers raised that some residents could not understand English. In response to this feedback, Yuan et al. [85] suggested incorporating songs in languages other than English into the robot to meet these residents' language needs better. The study by Bäck et al.[80] used NAO for demonstration of physical exercise. In response to the feedback from healthcare providers that residents with sight impairment could hardly see the robot and the residents with hard of hearing could not hear the instructions by the robot clearly, Bäck et al. [80] recommended painting the arms of the robot in sharp colour and giving it a loud and clear voice to accommodate the visual and hearing needs. In the study by Cavenett et al.[86] using the social robot PARO for social interaction with residents, corresponding to healthcare providers' concerns that using the robot would add to their workload and interrupt their established workflow, Cavenett et al. [86] proposed acknowledging the concerns and discussing with healthcare providers to understand their work needs and explore how the use of robot could address these needs and fit with their existing workflow.

b) Increase Understanding of the Benefits of Using Robots

Another strategy is to increase healthcare providers' understanding of the benefits of using robots. The authors of the literature reviewed mentioned that when healthcare providers better understand the benefits of using robots, they will accept and use them more. For example, in the study by Huisman and Kort,[68] some healthcare providers supported using the humanoid robot Nao because they found that it could enhance the emotional well-being of residents and bring them joy. In the study by Kolstad et al. [87], some healthcare providers welcomed the social robot PARO because they found it could stimulate residents' functions, such as interactions with people. In the study by Follmann et al. [88], the social robot Temi was used to contact residents' relatives. Healthcare providers welcomed the robot because they found different benefits to it: It was easy for residents to use. It did not take the extra workload of healthcare providers as they did not need to stand by to provide supervision when residents were using the robot to communicate with their relatives. Healthcare providers could disinfect the robot quickly after residents use it.

In addition, the reviewed literature suggests letting healthcare providers learn that the relationship between healthcare providers and robots is not competitive but complementary, emphasizing that humans perform certain tasks better than robots. A collaborative approach leverages the strengths of robots and humans, ensuring a higher quality of care. For example, Cavenett et al. [86] used social robots to communicate with residents. Corresponding to healthcare providers' worry that robots would replace their communication role, the authors suggested that robots only complemented healthcare providers' communication role because robots could not catch the nonverbal cues of residents as capable as humans.

c) Review and Overcome the Safety Issues with Staff

The third strategy is to review the safety issues with staff and address their concerns. The study by Shin et al.[89] used the robot Smartwalker to guide residents to walk. Healthcare providers asked if the robot was safe, considering residents were prone to fall risks. Shin et al. [89] recommended incorporating safety designs into the robot. For example, when there were obstacles and stairs in front of residents, the robot would give audio warnings to the residents. In the study by Hung et al. [11] in response to healthcare providers' concerns about residents' safety that residents might fight over the robots, Hung et al. [11] proposed having risk assessment and management guidelines in place to avoid conflicts and violence over robots and guide healthcare providers on what to do in case these happen.

d) Boost Interests in the Use of Robots

It is crucial to boost the interests in using the AI-enabled robots from both the healthcare providers and the residents. The authors of the reviewed literature suggested increasing healthcare providers' interest in using robots. For instance, in the study by Chang et al. and Šabanović [90], the researchers used the social robot PARO with residents in public areas of long-term care so that healthcare providers could see the process of using the robot and witness how the robot provided therapeutic effects to residents. The researchers found that this raised the healthcare providers' interest in using the robot because they told the researchers that seeing how the researchers used the robot with the residents stimulated them to think about how they could use it in their work.

Since healthcare providers expressed concerns that residents might not be interested in using the robot, the authors of the reviewed literature also suggested increasing residents' interest in using robots to address their concerns. In the study by Robinson et al.[78] using the social robot PARO, Robinson et al. [78] proposed changing the robot's colour from white to a more appealing colour. Louie [91] recommended dressing up the social robot Tangy so that it looked more attractive. In the study by Hebesberger et al.[92] using the robot SCITOS to accompany residents doing walking exercises, the researchers suggested giving the robot a name so that residents felt the robot was more personalized and thus more interested in it. Also, in response to healthcare providers' comments that SCITOS's voice was too mechanical, they proposed giving the robot a more attractive, more natural voice.

e) Provide Training and Involve Staff in the Planning and Implementation

The last strategy is to provide training. The authors of the reviewed literature recommended training and support to healthcare providers. In the study by Huisman and Kort[68] using the humanoid robot NAO, Huisman and Kort proposed that the training should give healthcare providers clear instructions on how to use the robot for physical and recreational activities with residents. They added that time needed to be reserved for training. Otherwise, healthcare providers could not find time to do the training within their busy work schedules. They also recommended setting up a Helpdesk, which healthcare providers could contact by phone or email when they encountered any challenges using the robot. When healthcare providers were more familiar with using the robot, they recommended peer learning (i.e., encouraging the healthcare providers to support each other in using the robot.) In the study by Yuan et al.[85] Using social robot PARO and humanoid robot NAO for interaction and communication with residents, Yuan et al. raised the need for an instruction manual in place so that healthcare providers could refer to it after training.

Comparing findings with theoretical frameworks

As suggested, we compared our findings with PCPF and CFIR to further our understanding of the findings. The authors of PCPF [40] and CFIR [93] suggested that discussing all constructs in one paper is not feasible, so they recommended that users of their framework select a few most relevant constructs to the research. We select constructs most relevant to our review through team discussions.

Comparing findings with person-centred practice framework (PCPF)

In our review, one barrier to adopting AI-enabled robots is that healthcare providers feel that they lack the knowledge and skills to use the robots [71]. One strategy is providing training to healthcare providers so that they can improve their knowledge and skills [68]. The knowledge and skills needed to use robots to provide care may be part of “professional competence,” a construct under the “prerequisite” domain of PCPF. This construct refers to “the knowledge, skills and attitudes of the person to negotiate care options and effectively provide holistic care.” [36] (p3)

Another barrier mentioned in our review is that healthcare providers are concerned robots might replace human functions.[76] One strategy is to let healthcare providers know they are better at providing these human functions, such as communication, than robots, as they are humans [76]. The constructs “engaging authentically” and “being sympathetically present” under the “person-centred process” domains of PCPF help us further understand why healthcare providers are better than robots. “Engaging authentically” refers to “the connectedness between people, determined by knowledge of the person, clarity of beliefs and values, knowledge of self and professional expertise” [22] (p5). Robots cannot engage with residents “authentically” because robots are not authentic humans, even if they are equipped with AI. “Being sympathetically present” means “an engagement that recognizes the uniqueness and value of the patient by appropriately responding to cues that maximize coping resources through the recognition of important agendas in the person’s life” [36] (p5) The study by Cavenett et al. [86] in our review mentioned that humans are better than robots at responding to non-verbal “cues” of residents, which are a crucial element to show residents “being sympathetically present,”

The “shared decision-making” construct under the “person-centred process” domain of PCPF referred to “engaging persons in decision-making by considering values, experiences, concerns and future aspirations.” [36] (p5) This construct made us wonder why healthcare providers did not mention too much about how the lack of residents was a barrier to the adoption of robots or suggest involving residents’ voices in the adoption process, especially since many barriers the healthcare providers mentioned were related to the residents, such as potential negative impacts of robots to residents [49,74,75], perceived lack of usefulness of robots to residents [68,78,79], and ethical concerns related to residents [71,81,82]. One explanation might be that healthcare providers thought that they knew the residents well and could represent the voices of residents, so involving residents or not was not a concern from their perspective. Future studies might examine this further. Another construct is “health and social care/policy” under the “macro context” domain of PCPF, which refers to “the decisions, plans, and actions that are undertaken to achieve specific health and social care goals within a society.” [36] (p3). Healthcare providers in our review did not mention too much about the influence of health and social policy on their adoption of AI-enabled robots, although there were international and national policies about the use of AI, such as the guidelines by the World Health Organization [94] and Health Canada [95].

Comparing findings with the Consolidated Framework for Implementation Research (CFIR)

One barrier to adopting the AI-enabled robots mentioned in our review is healthcare providers' perceived technical complexity. [69] CFIR has a construct of "innovation complexity" under the "innovation" domain, which resonated with our findings. This construct states, "The innovation is complicated, which may be reflected by its scope and/or the nature and number of connections and steps." [37]

Another barrier is a lack of resources, such as time for healthcare providers to learn, maintain, and assist residents in using the robot, [11] robots [11], infrastructure like Wi-Fi and storage place [72], and maintenance costs [84],. CFIR has the construct "available resources" under the "inner setting" domain. [37] "Available resources" means "resources are available to implement and deliver the innovation." [37] This construct helps us think that the lack of resources is an organizational-level barrier, as the "inner setting" in our review context means the long-term care home (i.e., the organization). In other words, the organization needs to be involved in resolving these barriers.

The construct "need" is under the "individuals" domain of CFIR. [37] The "need" construct refers to "The individual(s) has deficits related to survival, well-being, or personal fulfillment, which will be addressed by implementation and/or delivery of the innovation." [37]. Our findings include barriers such as healthcare providers' doubted usefulness [80] and ethical concerns [82] about using robots for residents. The "need" construct helps us realize that these barriers are related to healthcare providers' concerns about the "needs" of residents. For example, in the study by Back et al.[80], healthcare providers doubted the usefulness of the humanoid robot NAO in facilitating exercises because its size was too small for residents with visual impairment to see it, and its voice was too soft for residents with hearing impairment to hear it: It does not meet the visual and hearing "needs" of residents. In the study by Papadopoulos et al. [39] on the humanoid robot Pepper, healthcare providers were worried about residents' privacy as the robot had a camera on its forehead: They were concerned about the privacy "need" of residents.

In our review, some healthcare providers hesitated to use robots because they were concerned that doing so would interrupt their existing workflow [72]. One strategy identified was to discuss with healthcare providers how to integrate the robot into their workflow [86]. The construct "compatibility" under the "inner setting" domain of CFIR helps us to understand that these are "compatibility" concerns. [37] "Compatibility" refers to "The innovation fits with workflows, systems, and processes." [37]

Discussion

This scoping review addressed two review questions: a) healthcare providers' perceived barriers to using AI-enabled robots in LTC and b) strategies to overcome the barriers to the adoption of robots. We identified barriers to adopting AI-enabled robots in LTC homes, including 1) perceived technical complexity and limitation, 2) negative Impact, doubtfulness, and ethical concerns, and 3) resource limitations. We also identified strategies to overcome these barriers to adopting AI-enabled robots, including i) accommodate various needs of residents and healthcare providers, ii) increase understanding of the benefits of using robots, iii) review and overcome the safety issues," and iv) boost interest in the use of robots and provide training.

As suggested in the introduction, LTC homes face the challenges of increased resident care needs and a shortage of healthcare providers. [3–5] Researchers and technology developers expected that AI-enabled robots could address these challenges by sharing the workload of healthcare providers. [6–8] However, according to the results of our review, healthcare providers had a different opinion. For example, some suggested that using robots would increase instead of reducing their workload, such as assisting residents in using the robots and cleaning them. [11] Some suggested that using robots would interrupt their existing workflow. [72] An explanation for the gap between researchers/technology developers' expectations and healthcare providers' opinions might be healthcare providers' lack of involvement in developing and researching AI-enabled robots.

Therefore, healthcare providers’ opinions did not align with researchers' and technology developers’ expectations that robots could address the challenges in LTC homes.

In this scoping review, healthcare providers identified a few ethical concerns about using AI-enabled robots. Frennert and Ostlunt et al. [96] summarized the main ethical concerns of using robots with older adults from previous literature. Although the literature summarized by Frennert and Ostlunt et al. [96] did not specifically address AI-enabled robots or long-care contexts, it could still be a good reference for understanding the findings on ethical concerns in our review. Some ethical concerns mentioned in the paper by Frennert and Ostlunt et al. [96] were found in our review, including concerns about the privacy of residents [71] and healthcare providers [83], deception to residents [82], infantilization of residents (as many robots, especially social robots, look like a toy) [81], just distribution of the use of robots in a group setting [11], and residents’ attachment to the robots and negative emotions triggered when they are broken down [71]. However, when Frennert and Ostlunt et al. [96] mentioned the ethical concern of human’s loss of control of the robot, they did not specify which aspects of control. In our scoping review, for example, in the study by Erebak and Turgut [77], healthcare providers mentioned specifically the control of decision-making. One possible reason healthcare providers in our scoping review highlighted control of decision-making is that among different aspects of control of AI-enabled robots, one discussed most in society is decision-making, the key feature of AI [97].

In our review, healthcare providers had different opinions on whether the AI-enabled robots should look real. Some providers suggested that residents preferred real people or pets and doubted that residents would be interested in robots if they were not real enough. [78,79] Corresponding to this feedback, some literature proposed making the robot more real by adding features (e.g., a more natural human voice). [92] However, some healthcare providers had an ethical concern that residents with cognitive impairment would be deceived that the robots were real. [82] Concern about deception was also previously discussed in the literature on non-enabled robots. For example, in the study by Koh et al. [98], healthcare providers raised their concern that residents misperceived a Joy for All companion cat as a real cat. We considered that the opinion divide would be even more intense as AI-enabled robots develop. Compared with non-AI-enabled robots, AI-enabled robots could be even more “real” due to AI technology. Future research might further explore this topic.

Recommendations

As suggested, a possible explanation for the gap between researchers/technology developers’ expectations and healthcare providers’ opinions on using AI-enabled robots is healthcare providers' lack of involvement in developing and researching AI-enabled robots. Previous literature on using technologies in elder care mentioned the importance of involving healthcare providers: [99] Working on the frontline, healthcare providers use technologies according to the context. Their experiences with technologies may differ from what researchers and technology developers expect. Thus, researchers and technology developers need to work with healthcare providers to understand, for example, what training they need, how they would the technologies support their work, and how the technologies can be incorporated into their established work routines and workflows. Involving healthcare providers and understanding their perspectives should increase their acceptability and sense of ownership and reduce their concerns about using technologies.

We propose that administrators be involved in addition to healthcare providers. Some barriers to using AI-enabled robots found in this scoping review could not be resolved without administrators’ involvement. For example, healthcare providers said they did not have time for training. [73] The administrators are responsible for reserving time for them for training. Some healthcare providers are worried about the safety risks of using robots. [49,74] Administrators need to implement protocols for assessing and managing the risks.

We propose that residents be involved in addition to healthcare providers and administrators. When we compared our findings with PCPF, it was interesting that healthcare providers in our review did not mention much about residents' involvement, even though they provided person-centred care. Residents are the users of the robots, and they can give feedback on using them.

All stakeholders, researchers, technology developers, healthcare providers, administrators, and residents need to get involved in developing and implementing AI-enabled robots. Each stakeholder has strengths to contribute: Healthcare providers know the potential day-to-day challenges of using robots as they work on the front line. Administrators know the policies and regulations of LTC, so they can advise on how to ensure that the use of robots aligns with these policies and regulations. Technology developers have technical knowledge about robots. Residents provide feedback as users of the robots. This scoping review explored barriers and strategies to overcome the barriers to the use of robots from the perspectives of healthcare providers. Future scoping reviewers may consider conducting scoping reviews on other stakeholders' perspectives.

Limitations of the Review

This scoping review included only items in English because of the limited language capacity of our team. However, in many parts of the world, there is rapid development in the use of AI-enabled robots in LTC homes. Relevant studies published in languages other than English may have been omitted. Future scoping reviews should consider how to search for and include items in languages other than English, such as including team members with language capacity other than English or using translation tools. Furthermore, a quality assessment of the included studies was not conducted. However, the scoping review methodology mainly focuses on identifying the breadth of existing research rather than evaluating the quality of evidence. [100] Lastly, the review only examined the point of view of healthcare providers, not residents. Future researchers may consider conducting a scoping review on the same topic but from residents' perspectives.

Conclusion

This scoping review examined the barriers to using AI-enabled robots in LTC homes from healthcare providers' perspectives and identified strategies to overcome these barriers to the adoption of such robots. We anchored our analysis in established theories, specifically the Patient-Centred Practice framework and the Consolidated Framework for Implementation Research, to guide our further understanding of the findings. By addressing the barriers and identifying strategies to overcome them, we hope to foster the effective deployment of AI-enabled robots in LTC homes.

Conflicts of Interest

This paper has no conflict of interest.

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Appendix 1: Data extraction table

Author, Year, Place	Literature type and Study Design/ Method	Setting, Population and Sample Size (if mentioned)	Type of AI-enabled Robot and Use of the Robot	Barriers to the use of AI-enabled robot (from healthcare providers' perspective)	Strategies to overcome the barriers
Bäck et al., 2013, Finland [80]	• Journal article • Interview, survey	• Nursing home • 24 residents, 13 healthcare providers	• Compact humanoid robot NAO • Demonstration of physical exercise	• Healthcare providers had reservations about using the robot for residents with later stages of cognitive impairment and/or certain physical impairments (e.g., sight impairment, hard of hearing) as these residents might not be able to follow the exercise cues of the robot	• Robots adjusted so that its cues to residents on exercise were loud and clear, which helped residents with later stages of cognitive impairment to follow • Arms of the robot were painted in sharp colour, which helped residents with sight impairment to follow • Healthcare providers present to assist residents if needed
Casey et al., 2020, United Kingdom, Italy and Ireland [84]	• Journal article • Interviews	• Nursing home, community • 38 people with dementia; 28 family carers; 28 healthcare providers and 13 managers	• Social Robot MARIO • Maintain memories through reminiscence; entertainment; give updates on the news and personal interests of the people with dementia; give reminders on events	Healthcare providers: • hesitated to use robots as they worried that robots might replace human interactions • hesitated to adopt the robots as they thought that the robots were not useful for people with later stages of dementia who might find it challenging to interact with the robots (e.g., touching screens) unless there was support • doubted the capacity of robots to provide individualized responses, cues, and care to people with dementia • wondered if the money spent on robots should be spent on hiring more healthcare providers	• Robots should: o include more features to better understand and communicate with people with dementia e.g., speech recognition o incorporate more human-like features o be easy for healthcare providers to use • More education for healthcare providers so that they can change their negative attitudes toward robots and be more prepared to work with technology
Cavenett et al., 2018, Australia [86]	• Conference proceeding • Interviews	• Residential aged care • 5 healthcare providers	• Social robots such as PARO • Social interaction	Healthcare providers: • resisted the new technology as it intervened in the established routines • hesitated to join the training and use the robots • lacked the knowledge and skills to resolve minor tech problems without trainings • were discouraged from using the robot by technical problems	• Ensure that healthcare providers are involved in the whole process of using the robots • Ensure to have conversations with healthcare providers on how the robots can be incorporated into their routines • Acknowledge that introducing the robots would intervene in the healthcare providers' current routine • Provide training to healthcare providers early • Clear information on the expectations of using the robots • Be transparent about the potential challenges of using the robots and explain their benefits during the robot introduction to healthcare providers • Be transparent about the time healthcare providers can spend on the robots (including maintenance and training) • Reassure healthcare providers that robots cannot replace human interactions

Chang and Šabanović, 2015, United States[90]	• Conference proceeding • Observational sessions; informal interviews with residents and frequent visitors; semi structured interviews with healthcare providers	• Nursing home • Residents, healthcare providers, visitors	• Social robots such as PARO • Social interaction	N.A.	Use the robot in public spaces with residents, so that healthcare providers can see the therapeutic effects of the robot on residents and encourage staff to use the robot in their work with residents
Chang and Šabanović, 2013, Taiwan [74]	• Conference proceeding • Observational field study; interviews; focus groups	• Nursing home • Managers, healthcare providers, family members	• Robotic vacuum Roomba, Autonomous mobile robot TUG, Social robot PaPeRo, Social robot Paro • Assist patients with daily tasks and social interactions	• Risks and concerns associated with robots, for example: o Roomba robots were seen as a potential cause of falls o The large size of the TUG robot was perceived as a hindrance, making it difficult to navigate through narrow hallways	• Robots should be used as assistants rather than functioning independently
Chen et al., 2019, Taiwan [101]	• Journal article • Cross sectional study; surveys	• Different settings including care homes • 416 of health professionals, care workers and management personnel	• Social robots, types of robots not specified • Social interaction	• Respondents had mixed views on whether social robots would be a threat to aged care services	N.A.
Christoforou et al., 2020, China [83]	• Journal article • Survey/ questionnaire	• Different settings, including care homes • 115 Nurses, researchers, university graduates	• Nursing robots, socially assistive robots, physically assistive robots • Nursing robots relieve burden from nurses allowing them to concentrate on tasks pertinent to their primary duties • Socially assistive robots for social interactions • Physically assistive robots provide assistance required to stand-up, sit and walk	• Robots would threaten healthcare providers job security • Robots deployed at home might replace personal contact and assistance, i.e. loss of companionship and increased isolation • Robots might violates privacy as they created the feeling of being under continuous surveillance	• Apply an ethical framework overseeing nursing robot operations
Doi et al., 2016, Japan[102]	• Book chapter • Assessment, questionnaire	• Nursing homes • 12 healthcare providers	• Social robot Sota • Gesticulate and speak words of starting recreations or encouragement	N.A.	The healthcare providers acknowledged and recognized that the robot shared their workload and saved their time, so that healthcare providers could spend more time with residents
Erebak and Turgut, 2018,	• Journal article • Experimental	• Nursing home • 102 formal	• Autonomous Robot AILA	N.A.	• Healthcare providers preferred a robot with less automation in decision-making functions

Turkey[77]	study	caregivers			• Healthcare providers preferred robots with a less human-like appearance
Follmann et al., 2021, Germany[88]	• Journal article • Questionnaire	• 2 nursing homes and 1 hospital • 70 residents, formal caregivers (number not specified)	• Social robot Temi • Communication/ to combat loneliness and social isolation	N.A.	Healthcare providers acknowledges advantages of Temi: • can allow direct contact with relatives • is easier to use than a tablet • can drive autonomously into quarantine rooms • can be left alone with residents with no supervision needed. • is with a surface that can be disinfected • provides entertainments (e.g., music or videos)
Hebesberger et al., 2017, Austria [69]	• Journal article • Mixed-Method design; observations; interviews; questionnaire	• Care home • 8 different healthcare professionals were interviewed; 70 questionnaires received from employees	• Autonomous robot SCITOS • Autonomous navigation and patrolling to check if doors were closed as needed and if fire-extinguisher was in place, greeting task at lobby	Healthcare providers: • did not know that they could use the robot • did not try to use the robot because it did not offer games • feared to damage the robot when using it • feared to make mistakes when using the robot • perceived that the robot might lead to irritation • were afraid that the robot would replace healthcare providers • became bored by the robot with its invariant programme, functionalities, and lack of interactivity were annoyed by the robot's voice output and repeated sentences with an artificial voice • found that robots had slow reaction times, little autonomy and navigation problems	Healthcare providers perceived that robots could: • compensate human mistakes • complement and improve human abilities • conduct everyday tasks that may tire human healthcare providers • bring potential economic advantage (e.g., robots could work all around the clock and have low ongoing costs) • elicit a positive atmosphere and make employees smile, laugh when interacting with the robot • Healthcare providers wanted more ways to interact with the robot besides touchscreen, e.g., through interactive language communication • Healthcare provides wanted robots with more natural voice, and even with local dialects
Hebesberger et al., 2016, Austria [92]	• Conference proceeding • Mixed-methods study; observations; rating scales; interviews	• Care hospital / care home • 10 residents being observed; 4 therapists participated in rating observation scale and interviews	• Autonomous robot SCITOS • As a companion for the walking groups in physical therapy with the following functions: o serving as a source of motivation o accompanying the walking group o supporting social interaction within the group by providing topics therapists and residents can talk about during the	Healthcare providers found that: • Older adults were not familiar with using touchscreens • Older adults with dementia would not be able to manage the menu on their own • Not all residents can be engaged with the robot at once Healthcare providers: • Experienced technical difficulties (e.g., the music and picture galleries were not always accessible with unstable Wi-Fi connections, robots did not respond immediately to	Healthcare providers' positive attitude towards the robot • Robots were funny, cool, exciting, and had positive charisma for older adults • Robots were easy to handle • Appreciated that the robot recognizing them as reference persons • Robot was a useful entertainment tool • Therapist felt relieved they could hand over own entertainment activities to the robot • Older adults were encouraged to interact with robots with the facilitation by healthcare providers • Personalization of robots with names

			sessions o providing an acoustic stimulus with playing musical background for singing during the walking periods or playing specific natural sounds in predefined areas of the building (e.g., playing the sound of cow bells in a corridor with paintings showing cows in a field) o offering entertainment and activation for the participants during resting periods (i.e. music and a picture gallery)	control-card) • Experienced excessive demand to handle the robot in case of technical problems • Found it tedious to adjust the music volume • Felt that there was a lack of flexibility in the system (e.g., adjustment of the robot speed and order of the songs)	
Huisman and Kort, 2019, the Netherlands [68]	• Journal article • Evaluation Study; interviews; observation; questionnaire	• 14 nursing care organizations (15 locations) • Interviews: 15 management and Board and 20 professional carers Questionnaires: 62 healthcare providers	• Humanoid robot Zora (NAO) • For pleasure and entertainment or to stimulate the physical activities of residents	• No collaboration for using Zora (NAO) • No support from colleagues • Healthcare providers were not aware that they were allowed to choose to work with the robot • Healthcare providers felt frustrated and disappointed as starting the robot took more time than expected Technical issues with the robot: • Short battery life • Poor listening proficiency and speech skills (speech is unintelligible, responses from elderly clients are misunderstood, leading to incorrect responses) • Too complicated to program activities • Few pre-programmed activities available • Communicating through the robot was difficult because healthcare providers have to type the words on the composer at the same time	• Improved short-term Wi-Fi access in the buildings • Included an implementation for future improvements of the ICT (Information and Communications Technology) infrastructures in the organization's agenda • Knowledge shared between professionals about using social robots, the tips for using the robot, and working with the robot in daily routines • Available instruction training and the Helpdesk by phone or email • Positive attitudes from healthcare providers: they felt more fun at work and happy when working with the robot; received enough time to learn how to work with the robot; perceived that the support to use the robot was sufficient and aligned with healthcare providers' needs; believed that residents were content when the robot was used; preprogrammed dances and games were funny for residents and residents were actively involved; preprogrammed music made residents reminisce; the robot added value for one-to-one situations (provoke interactions, emotions and stimulate clients); the robot stimulated residents to move, provides reactions from residents
Hung et al., 2022, Canada	• Journal article • Qualitative	• Two long-term care sites	• Social robot PARO • PARO elicits emotive	• Healthcare providers worried that the robot could be used as a weapon in	To prepare and provide: • Risk assessments and risk management to avoid

[11]	study; semi-structured interviews	• 30 long-term care frontline interdisciplinary healthcare providers, operational leaders, residents and family members, ethics experts in dementia care	responses and serves as a social companion	situations that involved behavioural events • The cognitive and physical disabilities of residents made safety risk a priority concern for healthcare providers • Concerns about the freedom to decline robot use by residents with dementia • With current healthcare providers shortage: perceived issues with extra work required for healthcare providers (charge, wipe, disinfect, maintain, and repair the robots, teach new healthcare providers and families about the robot) • Time required to provide education and ongoing support • Robots would not be used without support or training to use it • Nervous about the cost of the robot • Worried about robots replacing human care and visits	resident conflict/violence to prevent injury among residents • Practical recommendations on how to train and prepare healthcare providers, residents, and families effectively • Appropriate resources to balance workload Positive perception from healthcare providers: • Healthcare providers agreed that robots could offer support for social connection in long-term care
Jonas, 2022, Canada [103]	• Online news article • Pilot study, method not specified, collecting feedback from residents about interacting with the robot	• Nursing home • Residents and healthcare providers, number not specified	• Humanoid robot Grace	N.A.	• The robot could help with healthcare providers' workload in interacting with residents • The robot could help to improve the mental well-being of residents by interacting with them
Kolstad et al., 2020, Japan [87]	• Journal article • Qualitative study	• 3 nursing homes • Facilities' managers and nursing healthcare providers	• Socially Assistive Robots (Social robot PARO, Humanoid robot Pepper) • Communication robots Pepper is used for recreation, entertaining patients through games and karaoke	• Patients found Pepper loud and annoying • Patients that were not cognitively capable might find PARO less interesting • Required human workers and attention as the robots were not fully independent	• All robots worked with the mental wellbeing of the patients • Patients had an emotional relationship with PARO
Kriegel et al., 2019, Austria [104]	• Book chapter • Literature search; online questionnaires; expert interviews	• Different care settings including LTC homes • Expert interviews: 6 (1 nursing home director, 2 nurses, 3 graduate social workers for elderly	• Socially assistive robots • To support in-patient care for the elderly through social interaction and human users (such as employees, residents; Function-related support processes (e.g., transport of food, laundry,	• Lack of support services for technologies in the context of in-patient care for the elderly on: o integration and maintenance of existing and required software and information technologies o interface management between the different software programs	• Important to consider the technical, legal, economic, psychological, social, and ethical dimensions of the technologies • Provision of the appropriate interfaces, standards, and necessary infrastructures for embedding the social assistive robots in the complex supply system • The embedding of the social assistive robot

		work, 1 kitchen manager, 1 laundry assistant); online survey: 46 nursing home directors	care supplies); resident-related processes (e.g., communication, entertainment, therapy support)	• Other challenges: threats of data abuse, healthcare providers feeling being monitored by social assistive robots and artificial intelligence	technologies into the existing service processes • Provision of the training and involvement of the employees and residents involved • Respective acceptance on the part of employees, residents, and relatives towards social assistive robots • Availability of dedicated social assistive robots' services providers to enable and ensure hybrid services in nursing homes • Solutions and strategies adapted to the respective structural and process-related circumstances and preferences
Lehmann et al., 2021, Switzerland [82]	• Conference proceeding • Semi-structured telephone interviews; a self-compiled questionnaire	• A nursing home • 5 caregivers in a nursing home (the ward manager and the safety officer)	• Social robot PARO • Assist in the care of older adults • Provide companionship	• Shape of the robot: o caregivers found it difficult to imagine how the residents would react to the headless shape of the robot • Difficulties were seen in the aspect of hygiene • Healthcare providers perceived that: o residents might have less human contact o residents might be afraid of the robots o residents might be deceived ethically	N.A.
Li et al., 2022, Canada [73]	• Journal article • Surveys	• Long-term care home • 2 Robots and 81 participants into 10 sessions (5 resident and 5 healthcare providers) with approximately 8 people in each session	• Humanoid robots Pepper and NAO • Entertainment	• Concerns regarding training on how to properly use the robot and the added workload related to operating the robot • Concerns about the robot not being able to operate independently without supervision and being used only as an additional helper	• Both the healthcare providers and the resident groups had positive perceptions and attitudes towards the robots for the dance activity: o Dance therapy with robot made possessive effect on residents o Residents thought it was easy for them to follow the robots during the dance sessions • Suggestions from staff related to the future deployment logistics of such robots
McGinn et al., 2019, United States [49]	• Journal article • Qualitative and quantitative mixed study; thematic analysis	• Long-term care home • 2 female senior nursing healthcare providers	• Social robots, Stevie • Communication	• Noise of robot • Nonsterile surface material	N.A.
Melkas et al., 2019, Finland [72]	• Journal article • Qualitative study	• 2 care homes and 1 geriatric rehabilitation hospital • 35 care workers	• Humanoid robot NAO • Rehabilitation and recreational assistance, like exercise, music, games, dances, storytelling	• Time-consuming workflow integration, with personal resources required • Internet connection and storage and charging space required • Robot with a small size and low	• Ample time for orientation and training to all healthcare providers

		(nurses, assistant nurses, physiotherapists, and occupational therapists)		voice, which was not friendly to clients with eyesight and hearing impairment • Threat from robots to the sense of control at work • Conflicts spurred between healthcare providers working and those playing with robots	
Mitzner et al., 2018, United States [76]	• Journal article • Quantitative and qualitative study	• Residential nursing facilities • 14 healthcare providers	• Service robot PR2 • Assisting with caregiving tasks (light housework, IV use, infusion pump devices, dispensing medications, transfer)	• Afraid of healthcare providers' job replaced by robots • Afraid of possibility of making mistakes by the robots, especially some direct tasks for patients, like bathing and dressing	N.A.
Obayashi et al., 2020, Japan [75]	• Journal article • Quantitative and qualitative study	• Residential care home • 25 older people with 15 healthcare providers members (13 nurses and 2 care workers)	• Social robot Sota • Monitoring sleeping of resident by connecting to sheet-shaped body vibrometer (SBV)	• Flashing eye of robot at night might frighten residents • Perceived robots as an interruption as robots might wake up residents at night • Residents might lose interests due to robots' failure to build effective communication	N.A.
Papadopoulos et al., 2022, United Kingdom [71]	• Journal article • Qualitative study; semi-structured interviews	• Care homes • 23 care home workers	• Humanoid robot Pepper • Communication	• Robots not having all human traits and communication • Robots restricted to verbal style instead of other non-verbal communication • Older people were slow to adapt to new technology and they might develop negative emotions such as fear • Concerns related to the possibility of jobs being replaced by robots • Concerns over privacy of residents • Care providers were not equipped with enough knowledge related to robot, like scope and function, operation, and maintenance	• More systematic education and training in detail should be standardized in long-term care homes before robots are introduced • Familiarity with robots will maximize the benefits it can provide in long-term care settings and reduce care workload
Pedell et al., 2022, Australia [105]	• Book chapter • Qualitative study; participatory design; case study	• Long-term care home, men's shed • 60 residents • Healthcare providers (number not specified)	• Social Robot PARO • Communication	• Unfamiliarity with robot	• Invites residents to make clothes for the robots by knitting and crocheting (to help remove hesitation and fear when facing the robot by building connection) • Enable robot's responses to injuries (to stimulate the emotional response of residents and help enhance connection between them)
Pfadenhauer and Dukat, 2015, Germany [70]	• Journal article • Video-assisted Ethnographic study	• Nursing home • video footage, photos, informal conversations and team discussions,	• Social robot PARO • Communication and observation instrument	• Unable to move the robot into the room independently • Fear of the robot could replace human manpower	• Equip staff with carrying techniques of the robots

		and observation (number of staff participated not specified)			
Robinson et al., 2016, New Zealand [78]	• Journal article • Part of a randomized-controlled trial; this study only includes a session with observation and interview	• Aged care facility • 16 residents and 21 healthcare providers	• Social robot PARO • Companion for loneliness, relaxation, and socialization.	• Residents not interested in the robot because to them it was like a toy and not appealing to all residents	• The robot should be altered to be smaller, lighter, with a different colour, and be able to interact more and purr
Shin et al., 2015, Switzerland [89]	• Conference proceeding • Interviews and surveys	• Retirement homes • 23 residents and 8 healthcare providers	• Robot Smartwalker • Evaluates the appropriateness and usefulness of the walker and its gesture-based interface for the elder	• Improvements needed for the walker	• Improvements suggested: o Uphill/downhill support o A parking brake for safety o An ergonomically designed tiltable handgrip o Obstacle and stair recognition for warning, and more audible warnings
Tanioka et al., 2019, Japan [106]	• Journal article • Qualitative study (participatory action research method)	• Long-term care homes • Number of healthcare providers interviewed not mentioned	• Humanoid robot Pepper • Motivate for older adults to perform exercise and activities	• Required support from healthcare providers for patients according to patients' level of cognitive function	N.A.
Moyle et al., 2018, Australia [81]	• Journal article • Descriptive qualitative study, cluster-randomized-controlled trial with another toy without AI	• Long-term care facility • 20 care healthcare providers	• Social robot PARO • Interaction	• Worried about the cost • Concerns regarding healthcare providers' training • Concerns over ethical issues, for example, residents' feeling of being treated as a child	N.A.
Louie et al., 2014, Canada [79]	• Conference proceeding • Qualitative study	• Long-term care home • 43 individuals (health care healthcare providers and families)	• Social robot Tangy • Plan, schedule, and facilitate social and cognitive interventions: group recreational and one-on-one telepresence activity	• Mechanical appearance and synthesized voice • Lack of experience with modern technology, for example, some residents was fear of the robot because of their unfamiliarity with technology • Language barriers as half of the residents were non-English speakers	• Dress robots with clothes • Add translation functions • Incorporate reminding and prompting functions on game schedules, meals, and missed calls
Louie, 2017, Canada [91]	• PhD dissertation • Mixed study design with qualitative and quantitative study	• Long-term care home • Older adults and formal caregivers	• Social robot Tangy • Support multi-user activities, learn from caregivers, improve compliance by personalizing robot behaviours	• The robot was relatively slow on picking up healthcare providers' instructions	Healthcare providers positive perception: • The robot was easy to use • Low workload when using the robot • Different possible uses of the robot • Using the robot was enjoyable • The robot can be customized to residents' diverse

					needs
Yuan et al., 2022, Australia [85]	• Conference proceeding • Semi-structured interviews	• 6 residential aged care organizations • 11 healthcare providers	• Social robots PARO, Humanoid robot NAO • Increase communication and evoke caring behaviours	• If the healthcare providers did not take the robots seriously, for example, treating them as toys, the probability of the older adults' unacceptance towards the robots would increase	• Provision of appropriate training and to engage healthcare providers to run programs with robots • Provision of training manual that was easy to follow by healthcare providers with low level of digital literacy • Healthcare providers have sufficient knowledge about the robots • Engagement of people interested in technology to take on the role as key technology champions • Respected residents' perceptions of robopets while using them (for example, treating robot pets as real as how the residents though; using Nao to meet emotional needs of residents who could not speak English and program songs in their language) • Healthcare providers are active in the initiation of human-robot interaction and to guide the care that the robot can perform: o Created meaningful activities with the robot (NAO) for residents (e.g., doing a concert with the robot) o Involved NAO in residents' daily routines o Adapted the use of robots to individual needs (e.g., embed residents' past relationships with animals into their personalized care plans) o Match the characters of robots to the preferences of residents to enhance the robots' effective use o Use robopets in one-to-one activities to avoid residents' conflicts of the ownership of robopets in group activities • Healthcare providers recognized the potential benefits and values of the robots: o robotic pets had significant social and emotional benefits for residents living with dementia o reduce care healthcare providers job stress o expand healthcare providers' opportunities for providing social care o increase healthcare providers' satisfaction

Supplementary Files

CONSORT (or other) checklists

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.
URL: http://asset.jmir.pub/assets/73792881d7042379b91e0c283ec0e84c.pdf