



OPEN Human–robot interactions and experiences of staff and service robots in aged care

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The rise of robotics in aged care is transforming how older adults are cared for, addressing staff shortages and workload. Daily interactions with staff and residents highlight an urgent need to better understand and improve human–robot interactions. This study investigates how 34 staff interacted with 10 service robots in a regional Australian aged care facility over 5 years, focusing primarily on their experience with service robots that transported meals and laundry. Guided by the Almere model, the research employs a qualitative case study approach, drawing on observations, focus groups, and interviews with management, industry leaders, and frontline staff. Findings are categorised into Emotional Reactions, Human–Robot Interaction and Collaboration, Social License and Environmental Dynamics. Results indicate conditional acceptance of service robots with scepticism about the service robots' reliability and practical utility. Our study highlights the importance of a supportive environment, robust infrastructure and adequate training for successful robotic adoption. It also argues for engaging diverse multi-tiered stakeholders in investigating, designing, and implementing robotics in aged care, emphasising the role of social behaviours and interactions for what we propose as functional *social service robots*.

After completing our COVID-19 screening protocols, we were ushered to the CEO's office. He ordered coffees to be delivered by the Temi robot and excitedly described how the 10 robots in his regional aged care facility were cleaning and polishing floors, delivering laundry and food, and soon to be greeting guests. He had just finished trialling the robotic seal Paro and Abi, a colourful, playful-looking, child-sized, AI-enabled robot designed to speak multiple languages and entertain residents. Mr X believed in the potential of digital technologies to support the care workforce despite ongoing logistical challenges, including equipment failure and challenges with outdated and incompatible digital and physical infrastructure and systems. I have never seen so many robots in daily routine operation in aged care, with evidence of robotic integration everywhere we went – throughout the facility were signs stating, "Please Give Way to Robots" and "Robot parking/charging/ turning areas". I wondered: is this the future? If so, my initial impression was that this is kind of cool. I liked that these 'service' robots are not replacing care staff but doing the more mundane activities, transporting food/linen. But I wondered: what do staff, residents, and their families think? (Fieldnotes, 20/02/24, EM).

The above field note extract documents observations and discussions during a research visit to a regional aged care facility in Australia, whose industry leader as an early adopter describes themselves as 'the grandparent of robotics in aged care'. In 2019, they won a grant from the federal government to install and test the Lamson transport robot, with his aged care facility subsequently trialling 10 social and service robots in total. This paper documents the learnings from this innovation journey, exploring the experiences of the diverse stakeholder groups (management, nursing care, support staff, catering, cleaning, laundry) who work with these social and service robots in a real-world care setting. The aim is to understand staff experiences working with these technologies (usability and acceptability), and the barriers and facilitators to adoption.

Social and service robots in aged care

Robots are an embodied manifestation of artificial intelligence, varying in size and design tailored for intended tasks. In aged care, existing and predicted care workforce shortages^{1–3}, a rapidly growing, socially isolated aging population^{4–7}, and the rising demand for cost-effective solutions^{2,8}, drive an opportunity and a need for robotic adoption. In this sector, robots are typically categorised as social or service robots⁹. Research has focused on

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companionship, telepresence communication, homecare assistance and multifunctional robots¹⁰. Social robots are designed for human–robot interaction and to provide companionship, conversation and emotional support (e.g., talking, playing music, bingo). Robots can also be designed to offer physical assistance to carers, from enabling rehabilitation and movement (e.g., supporting exercise) to supporting staff with physical care tasks (e.g., lifting individuals, monitoring falls and aiding with bathing). Service robots perform repetitive non-industrial tasks and interact with, assist, and provide services to humans in various real-world settings, often helping with practical tasks such as cleaning and transporting items, including meals and laundry¹¹. However, service robots collaborate and interact with humans and other robots, pointing to their need for social cues and behaviours to be successfully accepted and implemented^{12,13}. Key factors influencing successful robot adoption in aged care include co-creation and customisation, staff training, integration into care workflows, stakeholder acceptance and robust ethical guidelines^{14–18}.

The promise and the peril of robotics: expectations-reality mismatch

The integration of robots into aged care settings presents both significant opportunities and challenges. Social robots like Paro the Seal, Jibo and Care-O-Bot can improve older adults' mood, loneliness, isolation, anxiety, their ability to interact socially and reduce medication use among residents with dementia^{10,19–22}. However, the reality of robot adoption often reveals a mismatch between expectations and outcomes. Studies report mixed experiences, with positive impacts frequently tempered by limitations such as small sample sizes and short-term engagements^{20,23}. Furthermore, research is even more mixed on humanoid robots in comparison to robopets^{15,24,25}. For instance, while some staff observed humanoid robots as entertaining and engaging for residents, others criticised them as a 'degrading modern nonsense' and 'a waste of money and causes additional work, when work is already so busy'²⁶. Additionally, staff believed the novel experience waned quickly, and they needed to be better trained and supported in using it as otherwise, 'it's just going to end up in the cupboard'¹⁵. This variability emphasises the need for more comprehensive research to make robotic adoption more seamless for staff.

Ethical considerations are central to the discourse on robotics in aged care. Staff express concerns about reducing essential human contact, fearing that reliance on robots may lead to isolation for residents who most need personal interactions^{25,27}. There are also concerns that robots might compromise residents' independence, privacy or even risk infantilising them and undermining their dignity²⁸. Additionally, there is apprehension about job security, with worries that robots could replace human roles within care facilities²⁹. These concerns are exacerbated by trust issues, particularly regarding privacy and surveillance³⁰. Extreme reactions, such as staff unplugging robots or covering them due to fears of being secretly recorded, illustrate the depth of these trust deficits³¹. Furthermore, staff's startling or frightening reactions to robots suddenly appearing highlight their unfamiliarity with the technology and a lingering prejudice, as robots are not perceived as predictable or reliable. Adding to these concerns is a growing sense of inevitability about robotic integration in aged care, seeing them as an unavoidable trend or even a 'necessary evil'^{29,32}.

While robots offer potential benefits for resident well-being and workforce support, mixed outcomes, ethical concerns, and staff apprehensions create significant barriers to adoption. Current research reveals gaps in balancing the benefits of robotic assistance with preserving human interaction, privacy, and dignity. Incorporating ethical design principles, such as attentiveness, responsibility, competence, and reciprocity, could help ensure that robots enhance, rather than undermine, the dignity and autonomy of residents³³.

Obstacles to the uptake of robotic innovation in aged care

Widespread robot adoption has been hindered by high development, purchase, and maintenance costs, integration challenges with existing care systems, and mixed acceptance among staff and residents^{14,15,20}. If robots are to become more mainstream in aged care settings, two key obstacles must be overcome. First, the value proposition. The economic investment in developing and deploying robots is high. It cost an estimated US\$20 million to develop Paro, with a retail cost of ~US\$7,000. The base costs of a social robot are ~USD\$1,200 per month to lease or ~USD\$37,000 to buy, excluding expenses related to software, maintenance, training, and support²⁰. The robot value proposition, therefore, only holds if care staff successfully incorporate them into their ongoing care practices - beyond a limited trial or research period¹⁵. Even in Japan, which has led the world in humanoid-robot research for decades, robots have not yet been fully integrated into the day-to-day operations of aged care due to cost and implementation challenges, as Wright³⁴ explains:

It is an inconvenient truth for the robot enthusiasts that despite the publicity, government support, and subsidies—and the real technological achievements of engineers and programmers—robots don't really feature in any major aspect of most people's daily lives in Japan, including elder care. There is some evidence to suggest that when robots are purchased, they often end up being used for only a short time before being locked away in a cupboard. the machines failed to save labour. The care robots themselves required care.

Second, as alluded to in Wright's narrative, the public must be supported on a robot learning journey, especially staff working closely with the robots. Care staff are often unprepared, ready, or educated to work with robots. Most people typically have high, unrealistic expectations shaped by popular culture and science fiction. These sources create an idealised image of robots; however, the current experience is often far less advanced. Too often, there is an overpromise on robot functionality and an under-delivery of practical solutions³⁵. This expectation-robotic capability mismatch results in disappointment, scepticism, and resistance. Indeed, the maintenance and troubleshooting of robots often require additional work from staff, adding to their existing routine³¹.

Research suggests that the implementation process in care setting requires (1) a clear rationale and planning; (2) proper staff orientation, training, and guidance; (3) a holistic understanding of the robot purpose, features, abilities and tasks; and (4) an understanding of the local environmental dynamics, including a leadership

champion and the technological/built form infrastructure where challenges of limited Wi-Fi connectivity, physical space, and technology support impede acceptance^{26,31}.

A robotic aged care: 10 service and social robots in a real-world setting

Despite ongoing research on social and service robots, gaps remain regarding their long-term integration and real-world usability across different staff and tasks (particularly practical ones like laundry and meal delivery). Therefore, this study explores the extended experience of multi-level staff with service robots in a real-world aged care facility, addressing the question, “What is the experience of multi-level staff with service robots in aged care?”

The study documents the journey of an Australian aged care facility that has persevered in implementing robots into their care system. It was established that staff were pushing trolleys nearly 9000 km annually, suffering work-related injuries and losing time with residents. In 2019, after seeing the robots displayed at an aged care conference, the facility decided to introduce a service robot to replace manual handling tasks, specifically transporting kitchen and laundry trolleys¹⁴. The use of robots subsequently expanded to include trials of floor cleaning and polishing robots, disinfecting robots and, more recently, social robots like Paro the Seal, Abi, and Temi, a telepresence robot that greets visitors. This paper explores the usability, acceptability, and impact of working with these 10 robots on aged care staff, focusing on the transport service robots operating for the longest time.

Methods

Research design

This study employed a descriptive qualitative case study design, with data collected through observations, focus groups, and interviews. Given its focus on the functional and social acceptance of robots in aged care, the Almere Model served as the theoretical framework to identify barriers and facilitators to adopting service robots and informing their design and implementation strategies^{11,36}.

Developed from experiments with older residents interacting verbally with three social robots, the Almere model identifies factors influencing actual use: Anxiety (ANX), Attitude (ATT), Facilitating Conditions (FC), Intention to Use (ITU), and several perceived attributes like Adaptivity (PAD), Enjoyment (PENJ), Ease of Use (PEOU), Sociability (PS), Usefulness (PU); Social Influence (SI), Social Presence (SP), and Trust (T). The Almere Model is particularly relevant to aged care for its focus on anxiety, attitude, and social influence, crucial in environments where staff and residents may be apprehensive about new technologies. Trust is also emphasised, highlighting how confident users feel about adopting social robots.

While originally developed and applied in quantitative research, the Almere model's structured factors provide a valuable lens for examining qualitative data relating to the complex emotional, social and operational dynamics of robot adoption in elderly care. This study adapted the model using its factors to guide a deductive coding process that allowed for a nuanced exploration of such factors in a qualitative context. Similar adaptations of quantitative frameworks for qualitative research have proven effective in technology adoption studies^{11,17,37,38}. We avoid distilling findings into a single, rigid, dominant factor by exploring the rich, nuanced insights that could correspond to multi-dimensional factors. However, limitations of this approach include the inability to leverage moderating factors typically assessed in quantitative analyses (e.g., demographics, prior experience) and the intended precise measurability of the original factors, which may narrow the scope of the findings. Additionally, this approach limits the data to the already established Almere factors, yet we aim to expand its understanding with rich data representation.

Studies employing the Almere Model have yielded significant insights into aged care settings^{38–40}. For instance, studies have found that trust and perceived usefulness are primary determinants of successful robot adoption, with high levels of anxiety often impeding robot acceptance^{11,40,41}. In a study of social robots in dementia care, social influence—particularly from peers and caregivers—was a major facilitator in fostering positive attitudes toward robots¹³. Another study emphasised the role of facilitating conditions in easing robot integration, showing that well-structured support and training for staff helped mitigate apprehension³⁸. Across multiple studies, the model has demonstrated that ease of use and enjoyment are pivotal in driving both resident and staff engagement with robots, reinforcing its applicability in assessing both functional and social acceptance of robots in these settings¹¹.

Research setting

Ethics approval was granted by the University Human Research Ethics Committee Charter (UHREC) (Approval Number 7765) in October 2023, and the research was conducted in early 2024. Participant recruitment and all study methods were performed in accordance with the ethics committee guidelines and regulations, including providing information sheets to eligible participants and collecting their informed consent through signed forms prior to their participation.

The case study site in regional Australia is a 120-bed residential aged care facility (RACF) and remains anonymous, located approximately 60 min from a capital city. The facility, surrounded by independent living accommodation, was built in 1954, spread over 17 acres. There are 200 staff (about 100 FTE), of which 85% of staff are female, and 80 volunteers. Guided by an awareness of the Almere model for technology acceptance in care, our research questions are: *What is it like for different staff to work with robots in an aged care facility?; what is the impact of robots on the care/work experience of staff?; and how well (or not) do these ten different robots integrate into and operate in a real-world aged care environment?*

Participants: humans and robots

We conducted an in-depth semi-structured interview with the CEO and a focus group with local industry leaders (who initiated and were part of the robot experiment; 8 people, including representatives of some of the robotics companies). All staff who regularly interacted with the robots were invited to participate in one of four different focus groups, depending on their job role: mid-line coordinators (16 people responsible for the delivery and management of all aspects of the facility, from clinical care to logistical operations); laundry and maintenance staff (7 people: laundry staff were responsible for washing, drying, folding and distributing linens and residents' clothing, while maintenance staff performed routine repairs and upkeep); the IT initiative committee (4 people, who managed IT for the facility); and the catering and food services staff (7 people responsible for food preparation and serving).

As part of implementing the robots in this RACF and in alignment with their values and religious beliefs, staff and residents participated in a “baptism ceremony” for the Lamson transport robots. The baptism involved naming the robots and celebrated their arrival¹⁴. Other steps in the implementation process involved updating Wi-Fi, trolleys, lifts and doors, installing software, placing tablets in wall brackets, creating docking stations and signs. Figure 1 shows a sign on the wall informing and reminding residents, staff and visitors that robots are in operation in this facility, along with the Lamson robot transporting food, the robot parking station with the different robot names (Robbie, Sparkle, Axel), and a robot on charge with personalised local RACF signage on it.

Participants in this facility interacted with 10 different social and service robots deployed in this aged care facility. Table 1 depicts these, alongside a summary of the key advantages and challenges of deploying the robots in a real-world setting not designed for robot operations.

Procedure

A two-day site visit to the case study RACF was conducted in early 2024. Participants' identities remain anonymous and are not identifiable. Data collection included an in-depth interview with the CEO, followed by a facility tour, a live robot demonstration, and five focus groups with key staff and local leaders. The interview and focus groups were recorded and transcribed, with the research team taking detailed notes. Focus groups lasted one hour and comprised a round table discussion with each identified staff group and two researchers; one led the conversation, and one took notes and supported the discussion. The focus group questions were designed to elicit discussions about the participants' experiences with the robots. Questions prompted discussions but were not restrictive to allow participants to reflect deeply with their peers. Each question corresponded to enquiring about one or more factors from the Almere model³⁶, shown in Table 2.

Analysis

The data collected was organised and analysed using a deductive approach against the factors of the Almere Model described below³⁶. Upon data immersion, researchers identified patterns in each focus group data and grouped them to align with each factor. Table 3 shows how this study's data interpreted the factors from the original Almere Model with definitions from its source material. These codes and definitions provided the theoretical foundation for our deductive analysis, enabling the categorisation of staff experiences with service robots. The table includes an additional column to exemplify each factor with a representative quote from our data, offering insights into how these factors manifested in the context of aged care. By doing so, we bridge the gap between the quantitative origins of the Almere Model and our qualitative context. We aimed to ensure each factor's meaning is contextualised within real-world aged care experiences.

Researchers then collated findings in a macro table comparing two axes: the Almere Model factors and the participant groups. This table enabled us to systematically map how different staff roles experienced and perceived service robots, highlighting variations in perspectives and the contextual nuances of robot adoption. Each finding was assigned a label to enhance clarity, traceability, and interpretability. These labels also revealed



Fig. 1. Robot signage, robots in action, robot parking and charging in the RACF.

Robot	Robot type and function	Date introduced	Key points
2 Lamson robots “Robbie” and “Axel”	Service robot–transports laundry and meals	2019–present. Still in operation	Robots are large in size The cost of the robots was high Currently achieving 60+ tasks per day with two robots Currently gaining 90 efficiencies Saving 4+ hours of labour per day. Purchase costs Require repairs and maintenance Connection to WIFI
1 Lamson robot “Sparkle”	Infection control robot–ultraviolet light disinfection	2019–present. Still in operation	New technology Strong UV light Large robot Can only be used at night when minimal staff or residents are not mobile Purchase costs
1 Robopower window cleaner robot	Window washing robot–cleans high-up windows	2023–present. Still in operation	Effective on smaller windows Much safer way to clean high-up windows Not expensive to purchase
1 Pudu robot	Delivery robot	2023. No longer in operation after a 4-month trial period	Interactive Very mobile Time saver Purchasing/leasing costs were not financially justifiable
1 Temi robot “Poppy”	Concierge robot–greeting and navigation guide	2024–still in operation, with trials and further development in progress	Interactive Mobile Conducts tours as scheduled Independent Friendly
1 RV Technology robot	Service robot	2023. No longer in operation after a 12-month trial period	Too light. Not powerful enough to navigate up a 15-degree incline with load
1 Paro the Seal robot	Social/companion robot	2023–present. Still in operation	Cute & cuddly Very interactive Residents take ownership of it Activities need to be monitored
1 Pudu Robotics robot	Wet scrubbing cleaning robot	2023. No longer in operation after a 4-month trial period	Scheduling issues Maintenance issues Reliability issues Purchase/Leasing costs were not financially justifiable
1 Aotingbots robot	Dry sweeping and vacuuming robot	2023. No longer in operation after a 4-month trial period	Scheduling issues Reliability issues Purchase/leasing costs were not financially justifiable
1 Abi, the robot	Social robot–conversational AI-powered robot.	Arriving in September 2024. Trial occurred in April 2024	Uses AI Facial recognition Speaks 90 Languages Sings and dances

Table 1. The different service and social robots trialled at this aged care, with key reflections.

Focus group questions	Almere model factors
1. What were your initial expectations about robots before they arrived?	Attitude, Anxiety, Intention to Use, Social Influence
2. How did the robots come about? Why?	Facilitating Conditions, Intention to Use, Perceived Usefulness, Perceived Ease of Use, Perceived Adaptivity
3. Tell us about memorable moments with robots, positive or negative.	Attitude, Perceived Sociability, Perceived Enjoyment, Perceived Usefulness, Use
4. What specific challenges or pain points do personal care workers encounter in daily tasks?	Facilitating Conditions, Perceived Ease of Use, Perceived Adaptivity
5. You use robots to do X. What else can they do? Are there any repetitive tasks you do now that a robot could do in the future?	Perceived Adaptivity, Perceived Usefulness, Use
6. Can you provide examples of tasks/activities where you feel human interaction is irreplaceable in the aged care environment?	Social Presence, Social Influence, Perceived Sociability
7. We know other providers use Pepper/Paro here at RACF. It seems the robots are mostly chore/task-oriented. Is that the right approach? Would you want those robots, and why or why not?	Social Presence, Perceived Sociability, Use
8. What concerns/reservations do you have about robots in your workplace? How could these be addressed?	Anxiety, Attitude, Perceived Ease of Use, Trust, Facilitating Conditions
9. What words of wisdom do you have for others?	Attitude, Social Influence, Intention to Use, Use
10. We are working on developing a social service robot. What would be useful?	Facilitating Conditions, Perceived Usefulness, Perceived Enjoyment, Social Influence
11. What final words do you have to describe your experience with the service robots – in 1 to 3 words, what would you tell others?	Attitude, Perceived Usefulness, Anxiety

Table 2. Interview and focus group questions aligned to the Almere model.

Code	Factor	Definition	Sample quote
ANX	Anxiety	Evoking anxious or emotional reactions when it comes to using the system	"When they first came, the word hate came up quite a lot. I did because I was fixing them all the time. They are just there. You're just used to it. Only in the last year, they felt normal." (MC)
ATT	Attitude	Positive or negative feelings about the appliance of the technology	"I wasn't going to let the bastards beat me." (ITC)
PENJ	Perceived Enjoyment	Feelings of joy/pleasure associated with the use of the system	"Poppy is loved. She brings coffee with a good attitude [although] she can't respond." (MC)
PU	Perceived usefulness	The degree to which a person believes that the system would be assistive	"[The Abbie robot] was a big game changer. Residents wanted to speak to it." (IL)
T	Trust	The belief that the system performs with personal integrity and reliability	"It's been four years since the implementation of robots, and most days they don't work. Some days it works." (ITC)
PAD	Perceived adaptivity	The perceived ability of the system to adapt to the needs of the user	"You move out of the way for a resident. Not residents have got to move out the way for a robot". (C&F)
PEOU	Perceived ease of use	The degree to which one believes that using the system would be free of effort	"When the robot board freezes, it's like a hot potato game, where multiple people come to try to fix it, but no one can. Then, the staff has to push the robot manually when it freezes." (C&F)
ITU	Intention to use	The intention to use the system over a longer period in time	"Have an open mind; they are the future, and they are here to stay." (ITC)
U	Use	The actual use of the system over a longer period in time	"And whenever there's a visitor, gotta use it. He puts his heading, robot out. So I've got to call out, even though I'm halfway through my shift. [...] So there's my time gone, just so people can look." (L&M)
SP	Social presence	The experience of sensing a social entity when interacting with the system	"Axel, the naughty robot. Always breaks down!" (MC)
PS	Perceived sociability	The perceived ability of the system to perform sociable behaviour	"The other robot uses rude language: 'Get out of my way'. The cleaning robots are cute, and the way they speak is cute." (L&M)
SI	Social influence	The person's perception that people who are important to him think he should or should not use the system	"I feel more confident about talking about robots than a lot of my friends [...] because of the experiences and what I've learnt by not [giving up]". (ITC)
FC	Facilitating conditions	Factors in the environment that facilitate use of the system	"We've tried to retrofit robots into an environment that is not designed for robots. It's designed for human beings to walk up and down the corridors [...] Consider residents on their morning walks, and staff pushing trolleys and robots pushing trolleys. Whose right way is it?" (L&M)

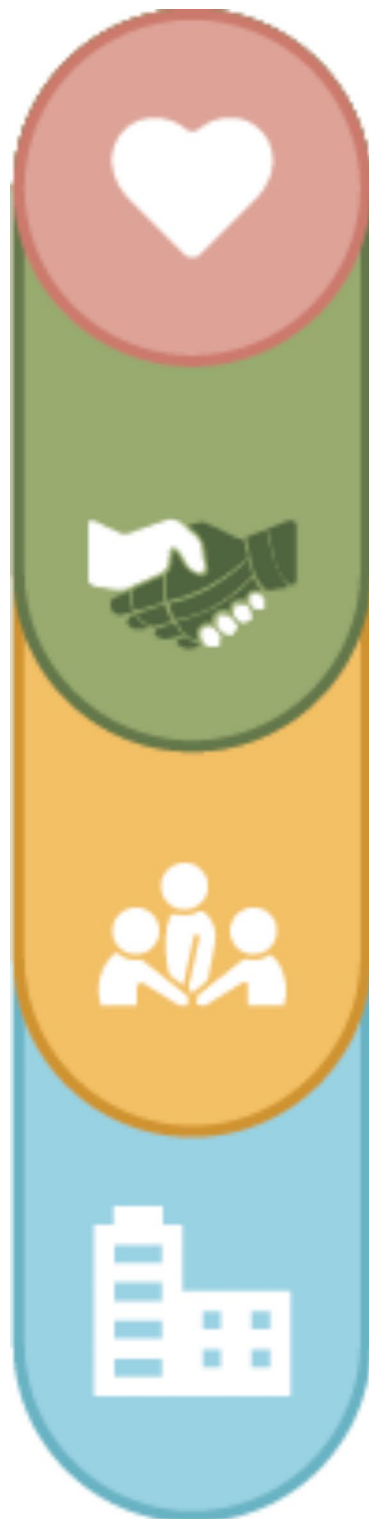
Table 3. Codes, factors, and definitions from the original Almere Model with contextualised examples.

broader patterns across roles, showing how specific factors complemented each other and contributed to overall acceptability trends.

While the initial coding adhered strictly to the Almere Model factors, further analysis of the macro table revealed that the data naturally grouped into broader themes. These themes reflect the original functional and social variables of robot adoption and address the practical and emotional aspects of implementation in aged care. For clarity and to accommodate word length limitations, the analysis condenses the original 13 factors of the Almere Model into four domains: Emotional Reactions, Human–Robot Interaction and Collaboration, Social License and Environmental Dynamics. The domains represent a redefined typology of use, reflecting how participants, particularly those most impacted by the innovation, experienced and interacted with the robots. Each domain highlights distinct aspects that must be considered and addressed during the planning and implementation phases of robot integration in aged care settings.

1. Emotional reactions to using robots (ATT, ANX, PENJ, PU, and T): This category captures emotions and attitudes that people express about robotics. It addresses whether staff personally perceive robots as a positive or negative influence on their work experience and performance. Emotional reactions—ranging from anxiety and fear (ANX) to enjoyment and satisfaction (PENJ)—are central to this category. It also examines how staff attitudes (ATT), trust in robots (T), and perceived usefulness (PU) shape their willingness to engage with robotic technology.
2. Human–robot interaction and collaboration (PAD, PEOU, and ITU): This category focuses on how well robots integrate into daily workflows. It includes factors like Perceived Adaptivity (PAD) and Ease of Use (PEOU), which evaluate whether the robots can align with or disrupt existing work routines. It also incorporates Intention to Use (ITU), assessing whether staff are willing to use the robots over time and whether the robots integrate effectively into day-to-day operations.
3. Social license (SP, PS, and SI): This category explores whether robots align with the social norms and cultural values of the workplace. It includes factors like Social Presence (SP), Sociability (PS), and Social Influence (SI), reflecting how robots are perceived as social entities and the extent to which peer and cultural expectations influence attitudes toward their use. In contrast to the first category, Social License is a collective experience rather than an individual perception.
4. Environmental dynamics (FC): This category captures the external factors that staff or robots cannot control but significantly influence adoption. These include Facilitating Conditions (FC), such as physical infrastructure, technical support, organisational implementations and other environmental dynamics that shape how easily robots can be integrated into the RACE.

The relationships and influences between domains are visually represented in Fig. 2. While each factor stands alone, grouping them into these broader themes highlights their interconnectedness and relevance to robot adoption. For example, Perceived Enjoyment (PENJ) could theoretically apply to both Social License and



Domain 1: Emotional Reactions to Using Robots

Represents staff emotions (from enjoyment to anxiety) that shape their attitudes towards robots and influence acceptance.

Domain 2: Human-Robot Interaction and Collaboration

Focuses on the direct interaction between staff and service robots and whether robots integrate effectively into daily workflows.

Domain 3: Social License

Represents how robots align with workplace social norms and cultural values.

Domain 4: Environmental Dynamics

Represents the external factors that influence robot adoption, like physical infrastructure, technical support, and organisational adaptations.

Fig. 2. Overarching themes of staff and service robots that guided our findings.

Emotional Reactions to Using Robots. However, our data emphasised its role in shaping individual work satisfaction and performance rather than social acceptability, so it was grouped under the latter. Similarly, external factors like Wi-Fi infrastructure and workspace design were centralised under Environmental Dynamics to highlight their impact as barriers or enablers outside the staff's immediate influence. The labels were chosen to maintain consistency with the theoretical framework and highlight how the grouped factors reflect both practical and emotional aspects of robot adoption.

Domain	Social attributes		
Factors	Social Presence (SP)	Perceived Sociability (PS)	Social Influence (SI)
Focus Group 1: Industry Leaders (IL)	Evident: Robots like TEMI and Abbie were acquired to enhance social presence, provide concierge services, interact with residents, and offer entertainment.	Sociable: Some robots like Abbie stood out for their ability to connect with residents personally and provide stimulating interactions.	Positive: Strong leadership and community engagement fostered positive social influence and broader acceptance.
Focus Group 2: IT Initiative Committee (ITC)	A tool: Robots were seen more as tools rather than social entities. They could not fully replace human interaction.	Functional: Robots were not perceived as companions. Their functional routine roles were prioritised.	Positive: Adoption success in other settings influenced attitudes positively. Staff wanted to influence educational institutions and the broader community, too.
Focus Group 3: Midline Coordinators (MC)	Limited: Minimal social presence was noted, with robots like the floor cleaner occasionally behaving socially.	Low: While some robots like Poppy were perceived as having a good attitude, robots lacked sociable behaviour.	Resistance: Peer circles resisted robots, valuing human interaction and expressing concerns about job replacement.
Focus Group 4: Laundry And Maintenance Staff (L&M)	Rare: Robots were rarely perceived as social entities, with most interactions being mechanical and functional.	Functional: Staff only noted one robot for its social behaviour, while others were seen as functional and obstructive.	Low: Staff felt unsupported by their social circle and the system to use or engage with robots.
Focus Group 5: Catering And Food Services Staff (C&F)	Machines: Residents and staff did not sense a social connection with them, as they were seen as mechanical and impersonal.	Rude: The robots lacked sociable behaviour. They did not interact with residents in a friendly manner, and their presence was often seen as disruptive.	Negative: Staff felt peer pressure to cope with the robots' challenges. Staff's social context created a cycle of resistance and mistrust.

Table 4. Extract from the macro table aligning Almere Model factors with participant groups.

Four Domains	Focus Group 1. Industry leaders (IL)	Focus Group 2. IT Initiative Committee (ITC)	Focus Group 3. Midline Coordinators (MC)	Focus Group 4. Laundry & Maintenance (L&M) staff	Focus Group 5. Catering & Food (C&F) Services staff
Emotional reactions to using robots	Positive perception	An exciting future	Unreliable, intrusive luxuries	Time-wasting nuisance	Rejection and displeasure
HRI and collaboration	Long-term positive investment	Complex machines we will make work	Prolonged adaptation process	Effortful and avoidable	Unadaptable and challenging
Social license	Evident sociable additions	Positive influential tools	Resistance to socialise with them	Functional systems	Rude machines
Environmental dynamics	Adaptations in transition	Poor internal and external systems	Poor physical and technical infrastructure	Poor logistics	Poor infrastructure and training

Table 5. Findings according to the Almere model showing how different staff groups perceive the robots—as the future or a nuisance.

To illustrate the diversity of perspectives and justify the grouping of factors into domains, Table 4 provides an extract focusing on the Social Attributes domain. This domain examines how robots align with social norms and cultural values within the workplace. Factors such as Social Presence, Perceived Sociability, and Social Influence were grouped under this domain due to their shared focus on how robots are perceived as social entities and the influence of cultural and peer expectations on acceptance. The extract demonstrates both the opportunities and challenges in robot adoption, showcasing how participant experiences varied across roles. The full macro table, which includes additional codes and complete insights, is available in the Supplementary File.

Results

Participants focussed their experience and comments on the service (transport) robots, as these have been in action for the longest and have had the most significant impact on tasks. Table 5 presents a comparison of the findings according to the Almere factor categories, with each focus group summarised in a few keywords. In terms of their overall experience with the robots, the industry leadership group were the most positive, and the staff on the ground (with the most direct contact) were the most negative.

Domain 1: emotional reactions to using robots

IL acknowledged moderate anxiety among staff and residents, with gradual adaptation and efforts needed to address safety and cybersecurity concerns. However, they argued that social robots like Paro and Abi brought joy to residents, particularly those with dementia, and Pudu and UV-light robots were valued for improving cleaning efficiency. ITC generally viewed robots positively, expressing cautious trust heightened by the reliability and economic viability of the technology.

In contrast, other staff were more critical. MC reported being initially resistant, “*hating*” the robots and even wondering: “*Why [robots]? We had many other options [of technology] like computers, more IT*”. In an already perceived busy environment, service robots like the Lamson exacerbated their anxiety, reporting robots disrupting the environment with loud, rude commands: “*Make way, robot coming*”. Moreover, frequent technical issues and the need for constant troubleshooting caused frustration and disrupted staff performance. Therefore, robots evoked mistrust and seemed unreliable in completing transportation tasks. Although MC appreciated the potential for robots to reduce specific manual tasks, especially the floor scrubber and food delivery robots, the benefits were overshadowed by the robots’ poor functionality and integration into daily workflows. While

enjoyable at times, robots like Abi and Poppy could be better integrated within staff workflows and the facility's established processes to be used effectively without adding extra operational burdens. MC saw potential in social robots but felt technology still required robust operational support and improvement to meet expectations:

The chit-chat robot [Abi] would work well if the technology caught up with what they're hoping to achieve. But I don't think the technology for us is there just yet. It needs to navigate a lot of conversation and a lot of voices. One-on-one is great, but it still needs a chaperone. That doesn't save time for us.

L&M and C&F staff initially thought robots would be helpful, yet their attitude shifted negatively when robots presented frequent malfunctions and additional work, increasing stress and disruption. They experienced moderate to high anxiety, worrying about the robots' impact on their routines, the noise, and the potential physical strain if they malfunctioned (as they were not designed to be manually moved). Despite occasional positive experiences and the acknowledged potential to handle heavy tasks, robots were typically more of a nuisance than a helpful tool. Since they got stuck, behaved unpredictably and needed supervision, they were described as "time-wasting", "inefficient", and "frustrating". The Lamson robot was especially mentioned as "absolutely useless". One shared a story where it got a resident's walker stuck in its sensor, while another described a robot being unpredictable: "They've pinned me up. It just came to me, and I went out of the way. It turned towards me and just came towards me. It eventually just stopped... it was a weird situation". There was a sense that management did not fully appreciate how hard it was to work with the service robots.

Domain 2: human–robot interaction and collaboration

IL viewed the bumpy robotic adoption journey as a "long-term positive investment", seeing the challenges (Wi-Fi compatibility, cybersecurity, uneven technical support, and a built facility not designed for robots) as feedback for innovation. Similarly, ITC viewed robots as "complex machines we will make work", as one explained: "I'm a risk-taker... and I wasn't going to let the bastards beat me". Conversely, frontline staff – those interacting directly with the robots – were more frustrated with the additional workload associated with trying to integrate robots into their workflows. MC lamented the prolonged adaptation process. Frequent breakdowns, time-consuming resets and constant maintenance made the robots challenging: "It is too stressful. The screen goes blank, and I can't get it going again". When the robots worked well, however, they were appreciated:

The food delivery robot is good because it saves the staff members from coming to the kitchen. So there's less foot traffic, and they can stay in their kitchen areas. If the laundry delivery robots work and do a good run, it's good. The floor cleaner robots... staff can't tell robots are doing jobs. They're done and dusted while everyone's sleeping... They're not bugging you; they're not blocking people walking around: they had to be moved around, maintained, cleaned, booted up, operated, repeatedly explained to residents, constantly monitored during use, and stored away afterwards.

However, L&M staff saw service robots as disruptive to their structured routines, describing them as "effortful and avoidable". When they broke or got stuck or had a "hissy fit and just stopped working for no reason", this caused delays in laundry delivery, with staff asking: "Why did we have to adapt to the robots? Could the robots not adapt to us?". When they worked, e.g., for 3 days in a row, staff could see their value. C&F staff also viewed the service robots as "unadaptable and challenging" and avoided using them when possible, saying: "I don't need to have any problems".

Domain 3: social license

IL and ITC valued robots' potential to enhance the aged care position as lead innovators. They knew that robots could not fully replace human interaction but could (when operating at full potential) allow carers to spend more personal time with residents. A "champion" figure was critical in supervising the robot integration and guiding staff during this often-bumpy change journey.

However, MC found the service robots disruptive, citing a need for "socially acceptable manners" (i.e., saying "please" and "excuse me" instead of "move" and "robot coming"). They wanted the robots to be more polite and engaging, like the Temi robot. Their influential social circles were wary of robots, fearing these replacing valued human interactions and jobs. Service robots were perceived as lacking distinctive social presence or identity to the point of getting confused with other robots: "We don't even know their names!". L&M staff used the robots because they had to, not because they found them beneficial. They worried about the presence of robots in an environment not designed for them, explaining that "residents look really stressed sometimes when the robot's behind them, and they can't move to the side because it won't go past them".

C&F staff also saw these robots as "rude machines" that were not even good workers – as one explained: "If we did what robots did, we would get fired!". Robots were seen as impersonal and incompetent tools rather than social entities that did not behave correctly with stakeholders in aged care: "You move out of the way for a resident. Not residents have got to move out the way for a robot". Despite perceiving robots as impersonal, C&F staff valued using robotic pets for residents with dementia to de-escalate violent reactions and improve social engagement.

Domain 4: environmental dynamics

Participants emphasised that the traditional aged care environment, with long, narrow corridors and non-automated doors, made robot operations challenging. ITC highlighted economic constraints and a lack of vendor support, explaining that "you cannot divorce economic constraints and economic viability in the production of robots". Despite IL arguing the environment was adapted to facilitate robot use (including facility re-designs, wider corridors, automatic doors, and dedicated charging areas), ITC lamented that poor internal and external

Domain 1: Emotional Reactions to Using Robots	Domain 2: HRI and Collaboration	Domain 3: Social License	Domain 4: Environmental Dynamics
"I like Poppy but it is too dangerous coming around the corners because it is too silent! You don't hear it coming." (L&M)	"Robots do not replace people – they assist people in doing their jobs more efficiently and give staff time to care for residents. And they are very expensive toys to have sit there. They don't just deliver food. They bring back linen and clothes and so on. Social and working (service) robots are different, and of course, staff and resident acceptance can be a challenge. How far, I wonder, can we take this?" (IL)	"Once they've (staff) had that further explanation, they're like, well, why not? For me, I feel more confident about talking about robots than a lot of my friends [...] because of the experiences and what I've learnt by not [giving up]" (ITC)	"It comes down to developing other champions, and we have some very good operational champions [...] but who might take on the project to see it into the future?" (ITC)
"It's a pain in the arse. And it's more stressful at night because there's only four of us here. And then you get staff walking in front of it who don't care. They just want to get to where they're going. So, whether there are robots there or not, or they want to sign off in a hurry, they'll just zoom through it. And the robot stops. So it jitters when it stops" (C&F)	"Nothing is perfect. For every negative, I could come up with 10 positives... because we have different robots, they behave differently and need different things. There is no end to this journey because we have just started. We have a cleaning robot, doing sweeping and vacuuming and a UV light, air purifier and disinfecting. 4 things in one. I say: take the chance, have a go, be open-minded. They are the future, and we need patience and courage to invest time in planning and scoping" (ITC)	"Our residents are still really reluctant in accepting robots, so their experiences are obviously different to ours, and because they live with the robots, when you say they have a positive experience, that's when the robots are happening in the background, and they don't even really realise that the robots are doing their jobs. So we obviously don't hear about those things." (MC)	"Everyone should know how to work it. There shouldn't be a new role as caretaker of the robot because one person gets all the pressure and responsibility. [...] Everyone needs to try and help. Why shouldn't others know what to do?" (C&F)
"And we need to extend the use of Poppy (Temi) from mainly coffee delivery to do more. The lifestyle team use Paro the seal very well with dementia residents, and I think Abi will be a game changer in terms of resident entertainment" (IL)	"It's taken a long time for us to learn the routines and the habits of the robots, as well as working cohesively with them. Our residents still find that struggling" (MC)	"What is it... Penny, Kenny, Poppy? We don't even know their names! Can't remember." (MC)	"How do we as an organisation have a bit of an insurance with our money that we've forked out all of this money today, and in six- or 12-months' time when new technology comes in, how do we have that insurance that will keep having current stuff?" (ITC)

Table 6. Indicative quotes for the domains.

systems were not set up for robots in time: “[robots] have been sitting here for so long but they couldn’t be operational because of everything else happening in the background that it was just, are we going to use these or not?”

MC and L&M also lamented the poor physical and technical infrastructure. They called for a robot-friendly environment, integrating different robot systems and dedicated robot supervisors to manage robot-related issues, e.g., resetting systems. They were reluctant to use the robots long-term because of their negative experiences and inefficiencies. C&F staff felt the combination of poor infrastructure and limited training hindered the robots’ performance and increased staff workload.

Longer indicative quotes from the focus groups concerning the Almere factors categories are included in Table 6.

Discussion

As Coeckelbergh⁴² reminds us, robots are not coming, “they are here, and they are here to stay” (p.3). Given the complex challenges that residential aged care providers face (e.g. workforce demands) and the need for innovative solutions, robotic adoption presents both opportunities and hurdles. Beyond acknowledging that there is more work to do to improve the consistent operation and function of service robots, there are many learnings we can derive from this case study that can inform decision-makers, care staff, designers, technicians, and other researchers for improved adoption and implementation of robots in aged care. Through the lens of the Almere Model, ultimately, these findings highlight the importance of developing strategies that (1) address perception mismatch, (2) design service social robots, (3) prioritise human-centric care, (4) establish a participatory implementation process, and (5) secure organisational support. Specifically, our findings point to the concept of *social service robots* as task-oriented robots enhanced with essential social attributes, which are critical for fostering trust, acceptance, and seamless integration in aged care settings.

Differences in perceptions: management vs. frontline staff

This study reveals a stark contrast in how management and frontline staff perceive service robots. IL and ITC saw robots as a valuable innovation that would bring return profits and position them as cutting-edge leaders in the industry after a long-term investment and hard work. An optimistic view tempered by the reality staff faced with the most constant interaction with robots. For MC, L&M and C&F, robots represented additional burdens that disrupted established routines. The main stressors were the challenging implementation process, the inconsistent robot use and functionality, and the ongoing need for human intervention to keep the transport robots operational. Although many participants could acknowledge the potential value of service robots for their work and residents’ well-being, they tended to agree that the robots in their facility were not there yet.

These findings align with Na et al.⁴³, who observed different perceptions of robots between care managers and workers in elderly care facilities. However, there is a notable difference: managers in their study approached robot adoption cautiously and carefully, highlighting robots’ inability to meet the complex mental and physical needs of elderly care. By contrast, managers in our study expressed greater hopefulness about the robot’s potential, while frontline staff focused on practical challenges and frustrations.

Similar perception gaps have been observed in hospitality and manufacturing, where leaders prioritised innovation while frontline staff remain wary of workflow disruptions caused by underperforming robots^{44–46}. Xu et al.⁴⁴ predicted the different anticipation of robots between hotel leaders and employees could negatively impact the organisational culture, morale, and structure. In line with Hoffman’s work³⁵, our findings suggest the

mismatched expectations create an environment of disappointment, scepticism, and resistance among staff to introducing more robots.

Designing service robots as social robots

Many participants mentioned that the service robots sounded abrupt and rude in their words and tone and asked: “*Can we design service robots with manners?*”. This criticism reflects a gap in the robots’ social attributes, where blunt commands like “*Make way, robot coming*” evoked anxiety and frustration among residents and staff. In contrast, when robots were first introduced in the facility, participants welcomed them with a baptism ceremony in alignment with the values and religious beliefs of the facility. This action demonstrates the thoughtful and human way of accepting the robots as members of the RACF community. However, due to the socially unacceptable behaviour of the robots, this welcoming message and integration attempt got lost in the robots’ implementation.

Despite the main functional purpose of transporting goods, our study suggests that—in settings such as aged care - service robots would benefit from some of the social characteristics and design attributes found in social robots. For example, research by Fong et al.⁴⁷ highlights the importance of empathic behaviours, personality, appearance and adaptive communication strategies in fostering acceptance and positive human–robot interactions. Breazeal et al.^{12,22,48,49} argue that such social attributes facilitate how we anthropomorphise robots and thus, interact and connect with them. Yam et al.’s⁵⁰ work goes even further to say that with successful anthropomorphism, people forgive robots’ shortcomings.

Incorporating polite language, culturally sensitive behaviours, and non-intrusive movement could help address concerns about robots’ abruptness and improve staff and resident perceptions^{51–53}. This would enable them to interact with staff and other direct/indirect users more effectively. Human–robot Interaction (HRI) and Human–robot Collaboration (HRC) approaches and design factors need to be better incorporated to go beyond using robots to do tasks to interact, collaborate, and work with robots effectively. Simple changes in robot behaviour, such as polite requests and local cultural language, could enhance their acceptance as collaborative partners. We propose that human co-workers’ acceptance will improve by considering and purposefully designing service robots as social service robots.

The term *social service robot* has been discussed in HRI literature, with Takanokura et al.⁵⁴ defining these robots as those capable of improving the quality of life for elderly users while simultaneously reducing staff workload. However, they primarily used Pepper as an example—a humanoid robot focused on cognitive stimulation, communication, and interaction in social tasks. While Pepper exemplifies a social robot with some service elements, the robots in our study, such as Temi and Poppy, are fundamentally service robots designed for task automation (e.g., food delivery, cleaning). These robots must be enhanced with essential social attributes, such as politeness, culturally sensitive communication, and approachability in order to succeed social license as a collective.

Therefore, in this paper, we define *social service robots* as task-oriented robots that simultaneously exhibit key social characteristics to facilitate interaction with staff and residents in aged care. Unlike purely task-focused service robots, the social service robots in our context are designed to improve human–robot collaboration through appropriate social behaviours. This definition stems from our findings, where participants consistently expressed a need for robots to engage in socially acceptable manners (e.g., replacing abrupt commands like “*Make way*” with polite requests). Consequently, we position social service robots as hybrid entities—combining functional utility with social capabilities to enhance operational integration and foster user acceptance in aged care settings.

Prioritising human-centric care over robot-centric practices

Robot-centric signs like “Please Give Way to Robots” introduced a notion of robots taking precedence over human workforce, a disconcerting concept that challenges the human-centric nature of caregiving. Such messages can inadvertently undermine the dignity of both residents and staff, creating an environment where technology is favoured, even at the cost of empathy and human interaction. This precedence also raises ethical concerns. It signals a subtle yet impactful shift in values, where operational efficiency is given priority over human-centred care. This can lead to resentment among staff, who may feel their work is undervalued. It also risks alienating residents, who may already feel vulnerable and might interpret the robot-centric environment as further dehumanisation of their care⁵⁴.

These concerns align with the ethical principles of Industry 5.0, which advocates for a shift from technocentric to human-centric approaches in using smart technologies to support workers’ well-being⁵⁵. Industry 5.0 emphasises leveraging robots to enhance human lives rather than replace them, aligning with the Royal Commission’s call for dignity and respect in aged care practices². Incorporating such human-centric principles ensures that robots serve as supportive tools, facilitating care rather than undermining it. Furthermore, Industry 5.0 represents a paradigm shift from Industry 4.0, focusing on integrating advanced technology into human environments without compromising humanity⁵⁶. This framework highlights the importance of using robots to assist caregivers in meaningful ways, such as reducing repetitive manual tasks, while upholding the relational and emotional aspects of care. Robot design and implementation must align with these values, prioritising respect for human dignity in every interaction. Doing so will allow robots to enhance caregiving environments without sacrificing the human connection at the heart of aged care.

Participatory implementation processes

The findings indicate that an effective implementation process must involve ongoing training, support, and clear role definitions. Although initial training and a naming ceremony marked the introduction of the robots, many staff members required continual training to manage them effectively. Some staff even took it upon themselves

to be the lead robot liaison person to add to their workload, noting all the “robot antics” in a notebook. As suggested in the findings, creating dedicated “robot supervisors” would provide comprehensive structural support and tailored plans for facility-specific training and technical support. Such a role would help address ongoing challenges and capture successes and failures as part of a continuous learning process to be shared and accommodated in the staff workload.

There should be careful consideration of the daily workflows and tasks that the robots are asked to do, with input from end-users and the staff who will be using them on a daily basis. Participatory design and co-design methods show that by incorporating the perspectives and interests of end-users in the design and development of novel technologies and products, their value and adoption improve^{57–62}. Furthermore, organisations can leverage demographic similarities to strengthen trust between staff and robots. For example, designing robots to share characteristics with employees, such as similar perceived gender, culture or communication styles, has been shown to foster community and trust in human–robot teams⁶³. However, organisations must balance this approach with caution, as building strong emotional bonds between staff and robots can lead to ethical concerns, e.g., unintended subgroups forming within teams. Managers should carefully assess these dynamics to optimise trust and mitigate potential risks during implementation.

To facilitate robot acceptance and impact, staff called for a robot-friendly built environment (from better Wi-Fi to wider corridors). A critical issue is that facilities’ spaces and physical environments will need to be thoughtfully re-designed, alongside technology support, to better accommodate the mobility and operational needs of robots³¹. To create such robot-friendly built environments, architects, planners, designers, and technology providers need to be aware of robot requirements from the early stages of robot procurement and building design or retrofit.

Securing organisational support

Service robots were introduced to this RACF by the higher levels of the organisation and can be considered a top-down diffusion of innovation approach⁶⁴. This means that the rollout plans engaged direct stakeholders of the service robots in the facility, staff and residents, only once the robot was in place or just before its arrival. While this strategy secured resources, it has led to unforeseen constraints, misconceptions and resistance. The implementation process and rollout of service robots are limited and understudied. Yet, our findings support the work of Melkas, et al.²⁶ and Ren, et al.³¹, who emphasise the need for robust planning and ongoing support to foster successful adoption. Furthermore, in line with Wright’s narrative³⁴, continuous training programs must be developed to support staff on an ongoing robot learning journey to improve adoption success.

Organisations planning to adopt robots must also address worker trust, a critical factor influencing robot acceptance. High levels of trust among human co-workers can diminish the likelihood of acceptance for robot co-workers, as workers may resist replacing trusted human colleagues with robotic ones that fail to work as expected⁶⁵. Conversely, service robots may integrate more smoothly into facilities by taking over simple and specific tasks and progressively increasing the support complexity. Assessing trust dynamics and tailoring adoption strategies accordingly can reduce resistance and optimise the integration of robots into human workforces.

While top-down rollouts have evident drawbacks, engaging decision-makers as stakeholders can secure essential resources (like funding), facilitate environmental adaptations and provide staff training -all necessary elements for successful robot implementation. Greater organisational support can be gained by considering staff requirements, interests, motivations, and involvement in decisions when selecting, procuring, and implementing robots into care environments.

Conclusion and future work

In closing, this research provides rare insight into how the aged care workforce experienced multiple service and social robots over an extended time through the lens of the Almere model. Findings suggest service robots benefit from more participatory or co-design methods to reflect end-users’ needs better. Considering service robots as social robots both in the design and use of these robots for aged care will help overcome adoption, acceptance, and implementation challenges. A limitation is that the focus of this study was on the workforce, meaning the voices of residents, families, and visitors are missing. Further work is needed to bring in the experiences of those stakeholders who were not part of this research. Additionally, further research regarding the co-design of aged care robots as social service robots is needed to evaluate their acceptance and impact on the well-being of residents and staff.

Future work will examine the role of design in developing robots for care and the design of robot-ready aged care environments. We propose incorporating the domains from this framework to inform our future research supporting RACFs interested in adopting social service robots into their facilities, covering user needs, emotional responses, social influences and environmental factors.

Data availability

Data is provided within the manuscript and supplementary information file.

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Author contributions

Author L.M. provided the research context and reviewed the factual information regarding the context and technology implementation to study. Authors E.M. and G.C. conceived and designed the research plan and conducted the research data collection. Author V.M. chose the methodology, transcribed, analysed and wrote the findings and discussion. E.M., G.C. and V.M. contributed to the manuscript writing.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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