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REVIEW

Ethical Design of Social Robots in Aged Care: A Literature Review Using an Ethics of Care Perspective

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Abstract

With interest growing in social robots for older people, it is crucial to consider how robots can be designed to support wellbeing and ethical values in residential aged care. By applying Tronto's ethics of care framework and the Care Centred Value-Sensitive Design methodology to existing literature, this paper investigates how caring values are expressed, achieved, or undermined in interactions among older adults, caregivers, and social robots in real-world aged care practices. We conducted a comprehensive review of 18 qualitative and mixed-method studies on the deployment of humanoid social robots in residential aged care settings. Our analysis of the literature through a care ethics lens identified ways in which robots may either augment or limit care. The analysis particularly highlights the ethical importance of effective collaboration among robots, caregivers, and designers. We argue that a care ethics framework can enhance such collaboration and thereby promote good care. We further propose four design principles to guide designers in integrating care ethics into robot design requirements. These practical principles should help to promote the wellbeing of both residents and caregivers in aged care.

Keywords Social robots · Ethics · Ethical design · Care ethics · Aged care · Older people

1 Introduction

Over the past few decades, considerable research has been dedicated to the development and deployment of social robots in aged care. Social robots are those robots that are capable of social communication and interaction with individuals [8]. The use of social robots in aged care has provided new opportunities for enhancing the wellbeing of older adults [1, 2, 5]. However, the design and implementation of social robots in aged care also poses risks and raises ethical issues concerning older individuals and their caregivers [16–19, 39, 72]. As robots are being introduced into this sensitive care context, researchers are emphasizing the need for incorporating ethical considerations into the design of new robots [64, 71]. Building on the ethics of care framework proposed by care ethicist Joan Tronto [65], Wynsberghe [78] proposed an influential theoretical approach that guides the ethical design of robots employed in care settings: the Care Centered Value-Sensitive Design (CCVSD) methodology [78]. The CCVSD methodology contends that the ethical design of robots should align with and promote the core ethical values outlined in Tronto's framework [65, 78].

To investigate whether real-life instances of the design and use of social robots in aged care align with the values outlined by Tronto [65], we conducted a literature review of qualitative and mixed-method studies on the deployment of humanoid social robots in real-world residential aged care. Drawing on Tronto's ethics of care framework [65] and CCVSD [78], this review aims to examine how existing research on social robots in aged care demonstrates or fails to demonstrate care-based ethical values in older adults' and caregivers' interactions with robots. While both robot pets and humanoid robots are commonly studied in residential

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aged care [2], we only focus on humanoid robots due to their ability to interact with older adults and their caregivers in more diverse and complex ways than robot pets [2, 81]. The relative sophistication of humanoid robots helps to highlight a wider range of considerations concerning robots and good care practice.

This review makes three contributions to the growing body of literature on the ethics of social robots in aged care. First, it reveals the potential negative impacts of current humanoid robots on the quality of care, despite the benefits robots can offer. These impacts stem from the robots' inability to provide the same level of attentiveness as human caregivers, and from robots imposing burdens on caregivers and potentially restricting their autonomy and capacity to care well. Second, drawing on the analysis of 18 empirical studies, this paper reveals that achieving ethical care requires collaboration among caregivers, robots, and robot designers/developers. Thus ethical appraisal of robots should consider the role of robot designers in addition to the elder/robot/caregiver triad proposed by prior researchers [3, 30, 81]. Third, this paper proposes a set of design principles that guide designers in effectively applying care ethics [65] and CCVSD [78] to robot design. These principles can serve as a roadmap for designing robots that support ethical values in care and promote the wellbeing of both older adults and their caregivers.

This paper begins by introducing the ethics of care framework [65] and the CCVSD methodology [78], which are the theoretical foundation of our review. We then explain our methodology which involves a comprehensive review of relevant literature that is shaped and guided by Tronto's ethics of care theory [65]. Subsequently, we present our results through the lens of Tronto's care framework [65], highlighting opportunities and challenges that robots may bring. Finally, we derive a set of practical design guidelines for robots and ethical care. For the sake of simplicity, we do not differentiate between robot designers and developers, and refer to them collectively as 'designers' in this paper.

2 Background and Theoretical Framework

2.1 The Ethics of Care Framework

Tronto's influential ethics of care framework [65] is built on care ethics theory developed by earlier feminist philosophers such as Carol Gilligan [26] and Nel Noddings [46]. In contrast to ethical theories such as deontology, utilitarianism, and virtue ethics, which emphasize abstract and universalized principles or excellent character traits, care ethics emphasizes interpersonal caring relationships and specific contexts in which care occurs [26, 46]. Care ethics highlights the importance of empathy, meeting needs, and developing caring relationships [46, 65].

Tronto expands care ethics theory into a wider political domain that goes well beyond family relationships. She defines care as a broad activity that includes everything people do to maintain and repair the wellbeing of themselves, others, and their environment [65]. According to Tronto, "providing an integrated, holistic way to meet concrete needs is the ideal of care" ([65], p109). She argues that a well-accomplished care practice should incorporate four interconnected phases, each corresponding to an ethical element. These ethical elements constitute Tronto's ethics of care framework [65].

The first ethical element in care is attentiveness, which occurs in what she describes as the first phase of care—'caring about'. Attentiveness requires caregivers to identify the real needs of care recipients and assess whether it is necessary to meet those needs. Tronto sees the recognition of others' needs as a first step in care since needs can only be addressed when they are accurately identified. She argues that "the ethics of care would treat ignoring others—ignorance—as a form of moral evil" ([65], P127).

The second ethical element in Tronto's framework is responsibility, and the corresponding phase is 'caring for'. After needs are accurately identified, responsibilities should be assumed by people or groups to address those needs. As care is transferred from family to social institutions, all the people and groups engaged in caregiving should take on care responsibilities [65].

The third ethical element is competence, which occurs in the phase of 'caregiving'. Competence requires the actual care work to be enacted so that caregiving can lead to positive consequences. If care cannot be provided due to caregivers' incompetence or lack of resources, then care will be limited or undermined, even if caregivers have good intentions. Tronto asks: "How could it not be necessary that caring work be competently performed in order to demonstrate that one cares?" ([65], P133).

The fourth ethical element is responsiveness, and the related phase is 'care receiving'. Responsiveness requires caregivers to understand how care has been received. It also addresses the power imbalances in caring relationships. Even if care is attempted, caregivers may sometimes misunderstand care recipients' actual needs; furthermore, new needs may emerge after care begins. Therefore, responsiveness requires caregivers to reflect on whether care needs are sufficiently met from care recipients' perspectives. Care is not complete without knowing how care recipients respond to care and what needs to be done next [65].

In these ways, Tronto's care ethics framework systematically outlines the features of different stages in an ideal care practice [78]. It has been used in a number of conceptual and empirical research studies to understand the meaning of good care and the impact of technologies in care practices (e.g. [6, 15, 29, 57, 58, 76]). For example, Yew has compared the core ideas in Tronto's ethics of care framework with other ethical approaches including deontology, virtue ethics, principlism, and utilitarianism when used in the design of care robots [80]. Yew's analysis suggests that Tronto's ethics of care framework is in some respects consistent with those other ethical theories, serving as a guiding principle for designers to foster users' trust in care robots [80].

Although there are several literature reviews on ethical arguments, theories, and challenges associated with social robots (e.g. [23, 25, 60, 72]), few of these reviews use care ethics to analyse ethical issues that are reflected in empirical studies. To our knowledge, the only work like our review is the literature review by Hewitt [29], which analysed the roles of robots in care using a care ethics lens. However, Hewitt's review [29] is relatively small in scope, focusing on only a few humanoid robots. In contrast, our review synthesizes a larger body of literature. It also goes beyond Hewitt's study by examining the entangled relationships among multiple actors involved in care, including robots, older adults, caregivers, and designers. By taking this approach, we provide a more comprehensive analysis of the ethics of using social robots in aged care.

2.2 The CCVSD Methodology

The CCVSD methodology builds upon the concept of Value Sensitive Design (VSD), which claims that technology products should align with and uphold human values [78]. It is specifically aimed at the ethical design of care robots in healthcare settings. CCVSD also employs the four ethical values established in Tronto's framework [65] as the core values to be promoted in the design of robots [78]. As Wynsberghe has noted, since Tronto's framework [65] contains a set of universal care values regardless of specific contexts, the CCVSD approach can be generalized to the design of various types of robots in healthcare settings [78].

To apply CCVSD in the design of care robots, Wynsberghe defines a Care-Centered Framework (CCF) consisting of five elements: context, practice, actors involved, type of robot, and the manifestation of moral elements [78]. Designers following CCVSD need to first identify the elements in CCF by designing the major functions and types of robots and the contexts and practices in which they will be used [78]. Thereafter, it is crucial for designers to evaluate how the robots will enhance or undermine the manifestation of the moral elements in a specific context [78]. These moral elements include attentiveness, responsibility, competence and reciprocity in a specific context [78]. Different from Tronto's framework [65] CCVSD [78] uses reciprocity instead of responsiveness as a core ethical element, as Wynsberghe emphasizes the reciprocal interactions between caregivers and care recipients.

While CCVSD [78] lays important groundwork for the ethical design of care robots, its practical application in empirical studies in human–computer interaction (HCI) and human–robot interaction (HRI) has been limited, particularly in the design of social robots for aged care. One potential explanation for this is that designers face challenges in predicting the consequences of introducing robots into care settings. Although older adults and caregivers can be involved in the design process, since they often have limited knowledge of robots, they may not fully understand the potential impacts of robots, especially without seeing the actual implementation of robots. Additionally, even with the same robot, different usage in varied situations may raise different ethical issues [55, 56]. Therefore, a CCVSD approach implies that designers need to understand the ethical implications of the deployment of robots in real-world contexts. The present paper seeks to examine the empirical evidence in existing literature to enhance understanding of how the use of social robots in real care practices aligns with the ethical elements in Tronto's framework [65]. This review extends knowledge of how Tronto's framework [65] and CCVSD [78] can shed light on the ethical design of social robots in residential aged care settings.

3 Method

3.1 Using Ethics of Care to Define Inclusion/Exclusion Criteria

We used Tronto's theory [65], with its four elements of good care, to guide the scope of paper selection and data synthesis. According to Tronto [65], care can be understood as a practice that includes the intertwined thought and action of those involved in care. This suggests that we can gain insight into care practices involving robots by examining the relevant actors' opinions, attitudes, and experiences, which influence their activities with robots. Since qualitative data best describes participants' opinions, attitudes, and experiences, we chose to review papers that reported qualitative and mixed-methods research.

Care practices involve both caregivers and care recipients. Since current social robots are not yet able to provide care to older adults without caregivers' facilitation, some researchers call for shifting the attention from a traditional dyadic interaction paradigm involving robots and older people, to a triadic paradigm that includes robots, caregivers, and older adults [3, 30, 81]. Accordingly, we chose studies that reported both older adults' and caregivers' experiences with social robots.

In the context of residential aged care, two types of social robots have been most widely deployed: robot pets and humanoid robots [2]. Examples of robopets include

Paro, a robot seal [32], and robot dogs and cats [38]. Older adults interact with them in a broadly similar manner as they would with actual pets [1]. Most humanoid robots, such as Nao [4], and Pepper [10] are programmable and can offer more advanced functionalities than robot pets. Interventions with humanoid robots are also more varied. For example, humanoid robots can function as daily life assistants and provide companionship and therapeutic training for older adults [5]. The complex nature of care situations, coupled with the sophistication of technology, make the interactions between older adults and humanoid robots more intricate and varied than those with robopets. Additionally, humanoid robots typically require greater facilitation from caregivers, which may present further challenges to care providers [81]. This suggests that studies on humanoid robots can better reflect the wider impact of social robots on the entangled relationships between older adults and caregivers in complex residential care environments. As such, we specifically review prior studies on the design and deployment of humanoid robots.

In summary, we only select qualitative and mixed-method studies that report both residents' and caregivers' experiences with humanoid robots deployed in real-world residential care settings in this review. Quantitative studies, studies focused on other types of robots or conducted in home settings, and studies that did not test robots with real users, were excluded. We also excluded studies that did not provide sufficient qualitative data about both residents' and caregivers' perceptions and experiences with robots. In cases where a similar study was reported in multiple papers, we included the paper that provided the most detailed information. Finally, only peer-reviewed journal articles and conference proceedings published in English were included.

3.2 Search Strategies and Outcomes

The review process generally followed the four-step framework outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which include the identification of relevant articles, the screening of articles based on predetermined inclusion criteria, data extraction, and the synthesis of findings [42]. However, in contrast to traditional systematic literature reviews, the first step of finding articles was conducted in two stages. This first stage involved the identification of relevant literature from the results of five existing reviews. The second stage comprised a systematic literature review of six databases. In the first stage, we selected five papers published between 2000 and 2018, and in the second stage we included 13 papers published between 2018 and March 2022. Our methods are described in detail below.

3.2.1 The First Stage of Paper Selection

Due to the significant number of studies on the design and implementation of social robots in aged care conducted in recent decades, many literature reviews have been published. These reviews have examined a range of topics, including older adults' perceptions and experiences of robots (e.g. [72, 73]), the impact and effectiveness of social robots (e.g. [1, 5, 32, 33, 54, 62, 74]), and caregivers' attitudes towards and usage of robots (e.g. [53, 55]). These reviews provide valuable insights into existing studies in this area, making them a useful resource for researchers. Since they are peer-reviewed and have already systematically screened studies from multiple databases, the choice to build our paper selection on the secondary data of existing reviews enhances the efficiency of the paper screening process while also ensuring that we included relevant and high-quality studies in our analysis.

In the first stage of paper selection, we built our selection on five existing literature review papers that used a systematic or scoping review method to review studies on robots used for older adults and published within the past five years [5, 24, 54, 63, 82]. Using papers included in these reviews as a paper data pool, we searched for papers within that pool based on our selection criteria.

The five existing reviews included a total of 200 papers that were published between 2000 and 2019. We carefully read the synthesized results in the five reviews and manually selected 7 articles that meet our inclusion criteria. After removing duplications, 5 articles were included in our review. Of the pool of 200 papers, most were excluded from this review because they did not report qualitative research, were not conducted in residential care settings, did not focus on humanoid robots, or did not include both older adults' and caregivers' experiences. The details are shown in Table 1.

3.2.2 The Second Stage of Paper Selection

In the second stage, we undertook a systematic literature review following the four steps outlined in the PRISMA guidelines [42]. We searched six electronic databases including ACM Digital Library, Web of Science, Compendex, Inspec, Scopus and PubMed using a combination of the following terms: (care OR healthcare OR social*) AND (old* OR aged OR aging OR eld*) AND (robot OR robots OR humanoid) AND (service* OR care home* OR nursing home OR long-term OR residential) NOT (sex* OR cancer OR autism OR child* OR infant* OR young* OR surgery* OR medic* OR pediatr* OR paediatr* OR seal OR Paro OR animal OR pet OR review). The literature search was conducted in March 2022. Since four reviews we used in the first stage incorporated articles published before 2018, in this stage the database search was restricted to articles published between January 2018 and March 2022.

Table 1 Details of paper selection from existing literature reviews (stage 1)

Review studies	Aim of the review	Paper inclusion criteria	Number of searched databases	Number of papers included	Publish year of reviewed papers	Number of papers included in our review
Shishehgar et al. 2019 [63]	To evaluate the effectiveness of robots in assisting older adults	Studies that involve older adults and robotic technologies for assisting aged care	7	58	2000–2015	0
Zafrani and Nimrod 2019 [82]	To review studies on older adults' interactions with robots	Studies that described older adults' experience with robots	5	65	2000–2017	3
Andtfolk et al. 2021 [5]	To identify the benefits and challenges of humanoid robots in aged care	Studies on the use of humanoid robots in caring for older adults	2	12	2013–2018	0
Papadopoulos et al. 2020 [54]	To identify the facilitators and barriers to the implementation of humanoid robots in aged care	Studies on the imple-mentation of humanoid robots in health and social care settings	9	12	2008–2018	3 (1 duplicate)
Ghafurian et al. 2021 [24]	To evaluate assistive robots developed for dementia care	Studies that applied assistive robots with real participants in dementia care	4	53	2002–2019	1 (duplicate)
Total				200		7
Remove duplicates						5

The initial search yielded 1038 articles. After removing duplicates, we carefully screened the titles, abstracts of the articles, and then conducted a full-text screen for relevant articles. Finally, 13 articles were considered eligible according to the paper inclusion criteria. Combining the results in two stages, this review included a total number of 18 studies. The process is shown in Fig. 1.

Data Collection and Synthesis A top-down approach was employed in data analysis for this review. Initially, information was extracted on the features of robots, their use in care activities, and the positive and negative feedback from participants in each paper. The findings were then grouped according to the four ethical elements in Tronto's framework [65]. Due to the interconnectivity among the four elements, some findings aligned with more than one ethical element. In these situations, the findings were clustered to the element that best reflected the changes brought by robots. Information that was not relevant to any of the ethical elements was excluded from the analysis. The first author conducted the data search, data extraction, and analysis, while all members of the research team discussed the results. This collaborative approach ensured the reliability of the analysis.

4 Results

4.1 Overview of Included Studies

This review included 18 papers, reporting on the implementation of 12 different types of humanoid robots. Pepper was the most commonly studied robot, with four studies employing this robot [10, 11, 52, 77]. Two studies used Zora [31, 41] and another two studies deployed SCITOS [27, 28]. The remaining studies reported on the use of a range of other robots, including Kompai [9], MARIO [12], Sanbot Elf [34], YORISOI Ifbot [36], Robovie-R3 [47], ComRobot [49], Kabochan [51, 52], Robovie2 [59], Telenoid [79], and My Real Baby [67]. A detailed summary of the results is presented in Table 2.

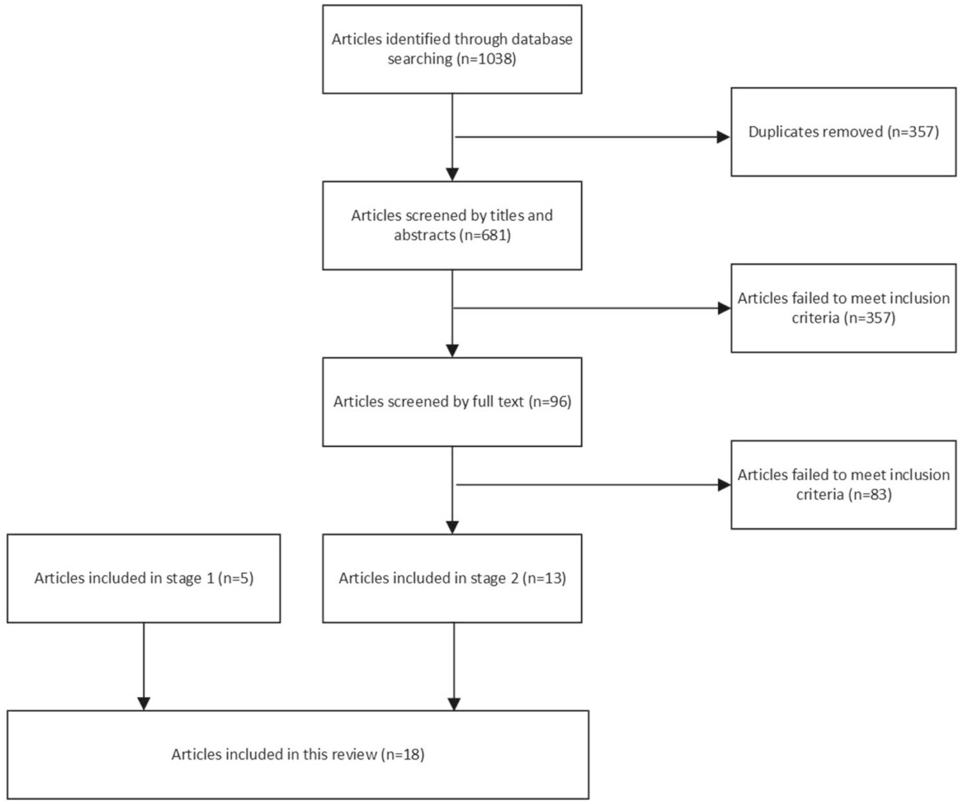


Fig. 1 Flow diagram of the paper screening process

Most of the studies aimed to assess the effectiveness of robots and explore the experiences of residents and caregivers with the robots. However, one study especially investigated the ethical issues raised by the use of robots [34]. All studies were published between 2006 and 2022, with eleven mixed-method studies and seven qualitative studies. These studies do not directly invoke Tronto's ethics of care framework [65]. Our aim is to interpret those studies in the light of Tronto's framework [65] to understand how social robots may affect values in care. Below we report on how the reviewed studies connect with the four elements in Tronto's framework [65].

4.2 Four Ethical Elements in Care Practices Involving Robots

As noted, the four elements in Tronto's care framework are attentiveness, responsibility, competence, and responsiveness [65]. Our analysis of the literature shows that humanoid social robots in aged care can affect these four important dimensions of good care in both positive and negative ways.

4.2.1 Attentiveness: Robots Cannot yet Achieve the Level of Attentiveness of Human Caregivers

According to Tronto, attentiveness involves accurately recognising the real needs of others. In the reviewed studies, the robots were unable to recognize and respond to the emotional needs of residents. The study by Jaakola [34] included two examples. In one, an older adult talked with a robot about his worries about whether a nurse gave him the correct doses of medicine, but the robot gave an answer that dismissed his emotional needs. Another older adult talked about her traumatic memories when the robot played some songs, but the robot could not understand her needs and still played music that made her feel sad.

Another problem is that the design of some robots in the reviewed studies did not accommodate accessibility needs for some residents with sensory impairments, such as age-related vision, hearing, and mobility decline. These accessibility issues sometimes made residents' disabilities and vulnerabilities more visible and led to negative emotions. For example, Jaakola [34] found that a participant felt frustrated because she could not finish the exercise movements shown by the robot. In Carros et al. study [10], a participant had to withdraw because he could not hear the robot even with a hearing aid. Residents struggled to talk to the robots because the robots spoke too fast, too soft, or in a tone unfamiliar to residents [9, 28, 31, 36, 47, 49, 59]. In one example, a robot's flashing eyes frightened residents and disturbed their sleep at night [49]. These issues may also diminish older adults' self-esteem. Caleb-Solly et al. [9] found that some residents

Table 2 Details of papers included in this review

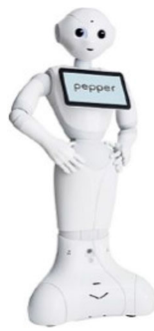
References	Name of the robots	Pictures of the robots	Interventions with robots	Methods	Aim of the studies
Caleb-Solly et al. 2018 [9]	Kompai		Showing photos and videos, delivering, games, reminders and exercise	Mixed-method	To evaluate the usability of the robot and understand users' experience with the robot
Carros et al. 2020 [10]	Pepper		Exercise, music, games, conversations	Qualitative	To understand users' experience with the robot
Carros et al. 2022 [11]	Pepper	See above	Exercises, games, music	Mixed-method	To understand how care workers appropriate the robot in their work
Wright 2019 [77]	Pepper	See above	Recreational, rehabilitation and exercise activities	Qualitative	To explore whether care robots can solve the shortage of carers
Casey et al. 2020 [12]	MARIO		Provide personalized music, calendars, photos, news and games	Qualitative	To understand users' experience with the robot
Hebesberger et al. 2016 [27]	SCITOS G5		Walking companion for group walking activities of people with dementia	Mixed-method	To understand the effectiveness of the robot and caregivers' perceptions of the robot

Table 2 (continued)

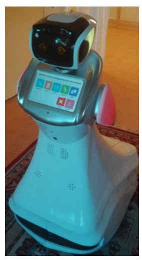
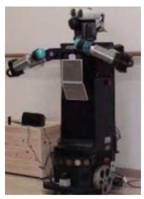
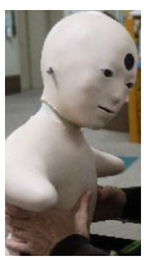
References	Name of the robots	Pictures of the robots	Interventions with robots	Methods	Aim of the studies
Hebesberger et al. 2017 [28]	SCITOS G5	See above	Moving autonomously in predefined areas and greeting people	Mixed-method	To understand users' experiences and acceptance of the robot
Huisman and Kort 2019b [31]	Zora		Music, exercise, stories, quiz, conversations and games	Mixed-method	To understand users' experiences and acceptance of the robot
Melkas et al. 2020 [41]	Zora	See above	Exercises, music, stories, dances, and games	Qualitative	To understand the impact of the robot
Jaakola2021 [34]	Sanbot Elf		Games, music, stories and exercises	Qualitative	To investigate how ethics is enacted in the field trial of robot
Kanoh et al. 2011 [36]	YORISOI Ifbot		Conversation, music, quiz, calculation and tongue twisters	Mixed-method	To evaluate the effectiveness of the robot
Nomura et al. 2021 [47]	Robovie-R3		Walking companion	Mixed-method	To understand the impact of the robot
Obayashi et al. 2020 [49]	Not mentioned		Monitor safety, proceed with messages, conversations	Mixed-method	To investigate the effectiveness of a connected system that includes a monitor and a robot

Table 2 (continued)

References	Name of the robots	Pictures of the robots	Interventions with robots	Methods	Aim of the studies
Osaka et al. 2017 [51]	Kabochan		Conversations and music	Mixed-method	To understand the relationships generated between residents, caregivers and the robot
Osaka et al. 2020 [52]	Kabochan and Pepper	See above	Kabochan: conversations and music. Pepper: exercise	Mixed-method	To understand the role of intermediaries in the interactions with robots
Sabelli et al. 2011 [59]	Robovie 2		Remotely controlled conversations	Qualitative	To understand users' experiences with the robot
Turkle et al. 2006 [67]	My Real Baby	Not included	Residents play with the robot in the way they like	Qualitative	To understand the relationships generated between older people and robots
Yamazaki et al. 2019 [79]	Telenoid		Remotely controlled conversations	Mixed-method	To investigate the effectiveness of the robot

tended to blame themselves when robots were unable to recognize their commands and responded incorrectly.

In all these situations, caregivers played an indispensable role in recognizing residents' emotional and social needs and facilitating their interactions with robots [9, 10, 36, 41, 51, 52]. For example, in the study conducted by Osaka et al. [51], a caregiver noticed that residents got confused about the incorrect answers to their questions given by a robot. In response, the caregiver answered the residents' questions and switched the robot from conversation mode to music mode, which successfully altered the residents' mood from confusion to enjoyment. Caregivers could also help residents to build trust with robots since many residents would not initiate interactions with an unfamiliar robot [10, 27, 52].

Many studies showed that residents and caregivers were strongly against replacing caregivers with robots [10, 11, 28, 34, 41]. Some residents were irritated that the robot could not offer the human contact they needed [41], showing verbal and nonverbal opposition to activities involving robots [34]. Caregivers expressed a general concern that their work could not and should not be replaced by robots [10, 11, 28, 41]. These examples show the limitations of robots in attending to the needs of residents and caregivers and highlight the importance of fostering helpful collaborations between caregivers and robots.

4.2.2 Responsibility: Robots May Add Responsibilities for Caregivers

According to Tronto [65], caregivers need to take responsibility for meeting care recipients' needs. With the introduction of robots, caregiving is undertaken by human caregivers and (in a loose sense) by robots. However, in the studies we reviewed, there was no evidence that the robots could be independently responsible for care. Furthermore, caregivers needed to take on additional responsibilities to ensure that robots could provide adequate care. For example, they needed to operate and maintain robots to make the best use of them. However, these tasks could add an extra burden to caregivers and make care work more challenging [10, 11, 27, 41, 77].

Some studies showed that contrary to the belief that robots might help alleviate caregiver burden, the caregivers, who already face burdensome working conditions, could be further encumbered by the deployment of robots. For example, in Carros et al. study [11], caregivers needed to frequently move a heavy robot between residents' rooms over long distances during the COVID-19 period. The robot came with an app that could be used to remotely control it, but its responses were slow, and it could not automatically navigate doorsteps. Transporting the robot was physically demanding for caregivers. Similar problems were found in studies with Zora [31, 41]. Since Zora could not yet interact with residents autonomously, caregivers had to type the words for the robot to speak during conversations with residents. A smooth conversation between robots and residents required caregivers to type quickly and accurately [31]. Additionally, organizing an activity with Zora required the assistance of two caregivers, one to operate the robot and the other to attend to residents [41]. However, many care homes were short-staffed, with normally only one caregiver available to facilitate lifestyle activities [77]. Therefore, care homes would need to hire more caregivers if these robots were used widely [77].

The extra effort of using robots may also take some of the caregivers' attention away from residents. Some caregivers described a robot as another patient with dementia who needed continuous care [27]. However, caregivers' time was a limited resource: many caregivers already face time pressure and tough workloads [41]. Some caregivers in Melkas et al. study [41] doubted the value of spending time on the robots. They felt that they should spend time taking care of residents instead of working on the robots.

Technical malfunctions may also add pressure on caregivers. Caregivers' responsibility is to ensure their organized care activities can meet residents' needs, but the malfunctions of robots may threaten this requirement [27]. Moreover, these malfunctions are often out of caregivers' control. Some studies found that caregivers were confused about why technical problems happened and how to solve them [11, 28] and were anxious about when technical problems might arise [11]. These uncertainties added psychological burdens to caregivers [11].

Studies show that tension caused by robots might result in caregivers feeling their needs and values were not being properly considered [41, 77]. Some caregivers asked why care organizations would prioritize purchasing expensive robots rather than raising their wages [77], and why care organizations introduced robots that added to their workload when they were already at full capacity [41]. Clearly, any additional burden imposed by robots may exacerbate ongoing concerns about the difficult working conditions that are already ubiquitous in aged care.

4.2.3 Competence: Robots May Either Augment or Limit Care

According to Tronto's ethics of care framework [65], competence is about ensuring that care is provided to care recipients in the right way. The reviewed studies showed that robots may contribute to ethical care, but they may also negatively impact caregivers' skillsets and autonomy. We present two subthemes related to competence: a) robots supplement or augment care, and b) robots limit care.

Robots Augment Care Some studies showed that robots could supplement gaps in existing care. For example, Sabelli et al. [59] found that a participant appreciated that the robot could greet him daily by his name, continuously offering him positive feedback. He commented that no one in the care centre responded to him in the way the robot did. Similarly, Turkle et al. [67] found that an isolated resident who felt abandoned by his family and friends could build a strong emotional attachment to a robot doll, using it as an emotional outlet.

Some studies showed that robots could fill in some gaps in caregivers' capacity or perform certain tasks that caregivers do not enjoy. Obayashi et al. [49] found that a robot which monitored safety at night could reduce the fatigue of caregivers. Wright [77] reported that caregivers who had fewer skills in organising recreational activities found Pepper was beneficial for extending the range of activities for residents. Melkas et al. [41] found that some caregivers who were uncomfortable instructing exercise movements publicly were happy that the robot could do this job for them.

Generally, many studies found that robots can lift residents' and caregivers' moods and create an engaging atmosphere [10–12, 27, 36, 51, 77, 79]. As a novel technology, robots can pique the curiosity of residents and caregivers [11, 28, 31, 47] and serve as a conversation topic that enables residents to build social connections [12, 36]. Some robots can provide recreational programs such as music, dance, and games, which can stimulate residents and reduce their agitated behaviour [11, 27, 36, 51]. When robots positively improved residents' wellbeing, caregivers felt a sense of work relief [11].

The positive impact of robots may, however, rely on caregivers' dedication to exploring how the robots can adapt to residents' needs. In the study by Huisman and Kort [31], caregivers tried to use a robot in different activities, finding that it worked most effectively in one-to-one situations to support caring for residents with dementia. Some caregivers in Melkas et al. study [41] emphasized that they needed to embed residents' interests into the designed activities involving robots. Other studies showed examples of caregivers helping residents to build trust with the robot by encouraging residents to talk to the robot and integrating it into residents' birthday parties [59]. Caregivers also programmed the robot to sing residents' favourite songs [11].

Robots Limit Care However, robots may sometimes diminish caregivers' capabilities and autonomy, such as when caregivers must follow rigid programs in the robots [27, 77]. For example, Hebesberger et al. [27] reported a study using a robot as a group walking assistant. Because the emotional and psychological conditions of residents living with dementia change frequently, caregivers normally arrange the tour of the walking group according to residents' conditions on that day. They also needed to frequently adjust their walking speed since residents' walking speeds were not the same. However, when a robot was used in this activity, caregivers had to follow the fixed route and speed that was programmed in the robot. The robot could not walk outdoors or easily change its speed to adapt to a group of residents. These rigid features restricted caregivers' ability to meet residents' dynamic needs [27]. Similarly, Wright [77] found that recreational activities helped caregivers to build relationships with residents. Caregivers enjoyed designing a variety of activities according to their knowledge and experiences. However, when Pepper was introduced into recreation programs, caregivers had to follow the standardized activities stored in Pepper. Wright [77] argued that the robot deskilled caregivers by making them robotic and weakened the relationships with residents.

It can also be difficult for robots to meet residents' diverse needs. This is apparent in the verbal conversations between residents and robots. Many studies found that residents could not have effective communication with them [10, 12, 28, 36, 49, 51, 52, 59]. For example, robots could not recognize residents' speech when residents could not speak clearly due to sensory or cognitive decline, when residents did not face the robots while talking, or when multiple people spoke simultaneously in group settings [11]. Additionally, some robots could only respond to questions or instructions that were pre-programmed. Yet older adults might talk to them about broad topics and express the same meaning in different ways. Some older adults also spoke in dialects. In these situations, the robots frequently provided incorrect responses that might confuse older adults [9, 10, 51, 52].

4.2.4 Responsiveness: The Different Roles of Caregivers and Robot Designers

In the studies reviewed, responsiveness—which Tronto defines as an ability to monitor and alter care as it progresses—was manifested in evaluations of the impact of robots by caregivers and researchers. Since in most studies researchers acted as robot designers, we can view their role here as designers. We found that caregivers and designers undertook different roles in response to residents' reactions to the robots. Caregivers tended to promote the use of robots in care work when they found that robots could positively influence residents. For example, they encouraged residents to communicate with a robot and made residents feel comfortable approaching the robot when they saw a benefit for residents [59]. Caregivers also acted, in a sense, as co-designers. In Carros et al. study [11], caregivers designed games involving the robots that were tailored to residents' preferences. Compared with the applications designed by researchers, the games designed by caregivers were better received and more frequently used by caregivers and residents.

Robot designers and researchers, on the other hand, collect residents' and caregivers' feedback on the robots and evaluate the impact of robots [10–12, 27, 36, 51, 77, 79]. In many short-term robot trials, responsiveness ends with researchers collecting users' responses. However, in some long-term studies, researchers further redesigned the robots according to users' feedback [10, 11, 31]. For example, in Carros et al. study [10], researchers found that residents could not be effectively stimulated if researchers were unfamiliar with the songs played by the robot. Consequently, they programmed the robot to ask for residents' favourite songs and play those songs. This change enabled the robot to better engage with residents. Similarly, in the study by Huisman and Kort [31], researchers solved usability issues with the robots that had been raised by staff, such as short battery life and weak Wi-Fi connection, and developed a virtual composer to enable staff to easily create programs without connecting to the robot. These examples highlight the caring relationship between designers (including researchers) and robot users, namely residents and caregivers. To enhance robots' capability to fulfill the needs of residents and caregivers in an ongoing fashion, it is necessary for designers to continue to be responsive to users' needs in a timely manner.

5 Discussion

In this review, we synthesized qualitative evidence of the manifestation of care ethics in the interactions among older adults, caregivers, and humanoid social robots when robots are deployed in residential aged care settings. Through the lens of Tronto's ethics of care framework [65], we highlighted how robots align with and challenge principles of care ethics. According to Tronto, care is a broad activity that aims to maintain people's wellbeing [65]. Care is often manifested in personal relationships, such as in families; but care can also go beyond these more intimate connections. On

Tronto's broader approach to care ethics, the service relationship between designers and robot users can be understood as a caring relationship, even when it does not involve face-to-face interactions. Robots themselves cannot provide the kinds of emotional and moral care that humans, especially those trained and experienced in care, can provide. Nonetheless, when robots are introduced into aged care practices, care is effectively provided to older adults through a collaboration among caregivers, robots, and robot designers. We have highlighted the intertwined relationships among caregivers, robots, and designers and we would argue that the design of robots should assist rather than impede these caring collaborations.

Consequently, robots should support caregivers in providing good care to residents, and designers should effectively pursue designs that align with the care ethics framework. This entails that designers attend to the needs of both older adults and caregivers, take responsibility and gain competence to meet their needs, and reflect on how their needs are or are not met by robots. Our perspective agrees with that of previous researchers who argue that care robots should supplement caregivers rather than replace them [43, 69, 72] and that the impact of robots should be evaluated through a carer/older people/robot triadic lens [3, 30, 81]. However, we extend previous research by adding the role of robot designers to the caregiver/older people/robot triad—which effectively expands the triad to a *quartet*, comprised of caregiver/older people/robot/designer.

Below we discuss four design principles that can guide designers to uphold an ethics of care approach when designing robots for residential aged care: (1) robot design should address the needs of both older adults and caregivers; (2) robot design should evaluate the cost–benefit profile of robots; (3) robot design should consider the division of labour between robots and caregivers; and (4) robot design should support the ongoing improvement of care. These principles help designers to apply the ethics of care framework—captured by the CCVSD methodology [78] for robot contexts—in concrete design work. Through examining interviews with roboticists who design and develop humanoid robots, Cheon and Su [14] have found that the values of most roboticists centre around engineering principles due to their technical background. Those authors called for more holistic values to be adopted by roboticists. Our review contributes to embedding the values of care ethics into design requirements for social robots in aged care.

5.1 Robot Design should Address the Needs of Both Older Adults and Caregivers

Our review highlights the crucial role of caregivers in the deployment of robots in aged care. Since robots cannot empathize with older adults or understand their evolving needs, caregivers are irreplaceable for building care relationships with older people. They are not just facilitators for older adults to use robots, but are also key users who seek to optimize the use of robots for care receivers. Although the ultimate goal of designing robots for use in aged care is to improve the wellbeing of older adults, caregivers' needs cannot be neglected, not least because their needs are entangled with those of residents. Thus, we argue that robot design should take into account the needs of both older adults and caregivers, to ensure that robots can support caregivers to provide ethical care to older adults.

Tronto [65] emphasizes that the needs of care recipients and caregivers should be balanced. Caregivers' interests may be impaired if they must always compromise their own needs for their care recipients' needs. This may in turn negatively impact the care provided to care recipients. Thomas Kitwood [37], who has proposed an influential theoretical model of person-centered care for people with dementia, similarly argues that caring for caregivers can improve the long-term wellbeing of people with dementia. Several empirical studies support the idea that neglecting caregivers' needs and wellbeing may weaken their willingness to provide compassionate care to older adults [22, 35].

According to care ethicist Nel Noddings [46], a key feature in a caring relationship is reciprocity, which emphasizes that caregivers and care recipients should provide mutual support to each other to enhance the wellbeing of both parties in the caring relationships. As we noted earlier, Wynsberghe [78] similarly includes reciprocity as a core ethical element that should be upheld in robot use. Accordingly, when designing robots that will be introduced to a caring relationship, it is crucial to consider how the robots can support reciprocal relationships between caregivers and older adults. A recent interview study by Yuan et al. [81] showed that mutual benefits can be achieved when the use of robots creates a virtuous cycle in which caregivers are motivated by using robots to increase the quality of care for older adults, while robots help to reduce their stress and give them a sense of fulfilment. This virtuous cycle can increase the effectiveness of robots for residents insofar as caregivers explore creative ways to use robots to meet the needs of older adults, and caregivers are motivated by the latter's improved wellbeing and responsiveness to care.

We suggest two approaches to address the needs of older adults and caregivers in robot design. First, designers should evaluate the impact of robots on the basic physical and psychological needs of older adults and caregivers. These needs, which include safety, work conditions, autonomy, competence, and relatedness, are grounded in Maslow's theory of motivation and needs [40] and in self-determination theory [21]. A prior study by Turja et al. [66] demonstrated the importance of assessing such needs when evaluating how robots might impact employees in workplaces. Given that people's basic physical and psychological needs are generalizable to various situations, they can also be used to interpret the impact of robots on older adults and caregivers.

Our review shows that the negative impacts of robots on older adults include situations where robots are unable to recognize and respond to their needs, where there is a mismatch between the capabilities of robots and residents' needs, and where there is a perception that robots may replace human relationships. These negative impacts can be interpreted as robots subverting older adults' needs for competence and relatedness as defined by self-determination theory [21]. Similarly, robots may also threaten caregivers' needs for safety and relatedness, as several studies have indicated that caregivers were concerned that robots might take over their jobs and disrupt their relationships with older adults. The impact of robots on caregivers' needs for autonomy and competence is reflected in the difficulties for caregivers in handling technical malfunctions of robots and the possibility that robots may restrict their autonomy. Therefore, it is crucial for designers to consider how the robots may support rather than compromise the basic physical and psychological needs of older adults and their caregivers.

Second, our review shows that robots can effectively augment or supplement care if they address the unmet needs of older adults and caregivers. The ethics of care framework emphasizes the importance of attentiveness in identifying unmet needs [65]. Accordingly, designers should recognize the unmet needs of older adults and caregivers and incorporate them into robot design. However, many studies did not provide sufficient information about how activities provided by robots could address the challenges faced by residents and caregivers. Many studies designed robots to perform similar entertainment, cognitive, and physical simulation activities [9–12, 31, 34, 36, 41, 51, 52, 77]. Although these activities may improve the wellbeing of older adults to some extent, it would seem that providing similar activities to different care homes fails to consider tailoring robots to address the unique challenges faced by each care home. We suggest future studies conduct in-depth contextual inquiries into the care settings and provide more contextual information about why designers choose to design certain features of robots and what changes robots can bring to the current settings.

5.2 Robot Design should Evaluate the Cost–Benefit Profile of Robots

While previous non-empirical research has discussed the potential tension surrounding responsibilities when robots cause harm, specifically regarding whether caregivers or robots should be held accountable (e.g. [3]), our review did not identify this issue. Instead, our review suggests that the use of robots may increase the burden on caregivers, as robots require additional labour and financial resources. This contrasts with the expectation that robots can alleviate the problem of inadequate resources in care homes. Tronto [65] claims that good care requires adequate resources. If robots consume the resources that are essential for providing quality care, they will conflict with caregivers' role in providing good care to residents.

Therefore, when introducing robots into aged care homes, it is crucial to evaluate the cost of robots against the benefits they may bring. Vandemeulebroucke et al. [73] argues that care organizations should conduct a holistic cost–benefit analysis of robot use. The costs of robots include financial and environmental costs, and organizational changes that are necessary to adapt to the use of robots. However, we would suggest that it should not only be the responsibility of care organisations to evaluate the cost of robots. Instead, designers also need to consider this issue in the robot design phase. Wynsberghe [78] argues that designers need to evaluate how the capacities of robots will change the roles and responsibilities of caregivers. As we saw, robots may require extra time and labour from caregivers and can bring uncertainty and complexity to care work. These burdens on caregivers cannot be ignored in design. The burden imposed by robots may sometimes force a re-evaluation of the wisdom of choosing robots for aged care. Given the complexity and expenses associated with using and maintaining a robot, alternative options, such as using cheaper technologies or developing more people-involved programs may sometimes be more efficient [29]. Our review revealed that playing music is a popular feature in social robots, but other inexpensive technologies, such as iPad and CD players, can also play music for older adults. These simpler technologies may place less burden on caregivers than sophisticated robots. If designers evaluate the cost-benefits of different options, they may find that robots are not the best solution in some contexts. Even though robot designers' central focus is on creating robotic technologies, they should also take on some responsibility for evaluating whether robots are suitable for particular care settings.

5.3 Robot Design should Consider the Division of Labour Between Robots and Caregivers

Previous researchers agree that for robots to be used ethically in care, they should not aim to replace human caregivers, but rather act as tools to assist caregivers [72]. However, the results in our review suggest that even when used as tools, robots may lead to negative consequences for caregivers, including deskilling and decreased autonomy. As Wynsberghe [78] argues, designers should assess the context and care practices that robots will be involved in and the capabilities of the robots to ensure that robot use can preserve ethical values in care. Results in our review suggest that ethical issues may arise because of inappropriate division of labour between caregivers and robots. When designing robots for aged care, designers need to think about what types of tasks are suitable for robots. Robots should be designed to empower caregivers and enhance their capacities, rather than undermine their capabilities.

Our review showed that current robots are not suitable for tasks that require caregivers to identify and respond to residents' diverse and frequently changing needs, such as walking with or talking to groups of residents with dementia. Robots may also cause problems in activities that require empathy, emotion, and interpersonal relationships. Nonetheless, robots can effectively help caregivers when the robots undertake tasks that require long and continuous periods of working, such as safety monitoring [49]. They may also assist in situations that involve large amounts of data, such as playing music and showing photos that relate to residents' personal lives [12].

These results suggest that designers need to consider the comparative strengths of caregivers versus robots in design. Since care is essentially contextual and relational [46, 65]. Even if humanoid robots have advanced artificial intelligence, they are far from being able to perform all required interactions across different situations in aged care. Considering the importance of caring for older adults' emotional and social wellbeing [20], it is questionable whether robots can handle complex care work at the same level as human carers [7]. Robots may undermine care if they play dominant roles in activities that caregivers are more skilled at.

On the other hand, robots have unique advantages. They are better than humans at storing and retrieving a large amount of data, doing tedious and repetitive tasks, and working in dangerous situations. They can also potentially provide constant nonhuman companionship to residents and have neutral attitudes towards older adults' negative emotions. Highlighting these features in robot design can help to augment caregivers' capabilities. For example, robots can help healthcare personnel when they enable remote communications and indirect contact during the COVID-19 period [75].

On the other hand, our review demonstrates that current robots have significant limitations in recognizing and understanding human needs. If robots are to be extensively employed in aged care, considerable improvements in the cognitive capabilities of these robots are necessary. These enhancements are crucial to ensure that the robots can effectively identify and respond to human needs and expectations [44]. Furthermore, the enhancement of cognitive human–robot interactions [44] can also foster better collaboration between caregivers and robots in delivering care. However, considering the vulnerability of older adults and the difficulties in interpreting the emotional needs of those with dementia, we maintain that human caregivers should always be involved in the robot-care partnership. Detecting individual emotional needs may be most effectively and appropriately accomplished by human caregivers.

5.4 Robot Design should Support the Ongoing Improvement of Care

Tronto [65] regards care as a continuous process, emphasizing the importance of responsiveness for ongoing care. Responsiveness of care is especially important in residential aged care settings, where residents' physical and psychological conditions are constantly evolving and where some residents pass away and new residents enter the care homes. This means that, where robots are used, there may be a need for continuous improvement and refinement in robot design. Since care for older residents is underpinned by collaborations between caregivers and designers, the continuous improvement of robots and their designs requires joint effort from both parties. While robots have the potential to enhance the quality of care, robot design needs to incorporate feedback and reflections by designers and caregivers on how robots can meet ongoing care needs in real-life practice.

We suggest two approaches to support the continuous improvement of robots to meet users' needs. One way is to foster designers' active involvement during the robots' lifecycles. In a recent study on the role of caregivers in facilitating the use of virtual reality in aged care, Waycott et al. [76] suggested that designers should consider the long-term experiences of older adults and caregivers after implementing technology in real-life settings. However, our review suggests that only identifying unmet needs in the implementation stage is not enough, since redesign and redevelopment of robots are often necessary. When examining designers' role from the caring relationships they formed with older adults and caregivers according to the ethics of care framework [65], we argue that designers should not only keep collecting caregivers' and older adults' feedback on robots, but also take action to improve the design of robots to address relevant unmet needs, and then reflect on the impacts of the improved design of robots. In other words, designers' work should go beyond the design and initial orientation periods and be sustained throughout the robot deployment phase.

The other approach is to increase the adaptability and flexibility of the robots to enable caregivers to customize the robots to suit the specific use cases [70]. Sustainable improvement of robots also relies heavily on the input from caregivers, who play a vital role in the successful domestication of assistive technologies [13, 61, 68, 76, 81]. Caregivers can come up with creative integration approaches to make the best use of technologies, and work as gatekeepers to control the potential risks that technologies may cause to older adults [61, 76, 81]. Given the complexity and diversity of older adults' needs, caregivers may need to change or redesign certain features of robots to adapt to different residents' needs. For example, caregivers may need to adjust the volume and font size of robots for residents who have hearing and vision loss. They can also contribute creative design ideas for games that are suitable for older adults' preferences and give feedback on which features may not be helpful for older adults [11].

One potential method to achieve adaptability is through modulization. The robots may be designed with separate modules to achieve specific functions so that caregivers can easily reconfigure these modules to align with contextual needs [70]. A more advanced step is to create intelligent robots with adaptive behaviours. This would allow the robots to learn from users and automatically adjust to users' actions and variations in the surrounding circumstances [45, 50].

In sum, we argue that robot design should support the joint effort of designers and caregivers in the ongoing improvement of robots. The relationship between designers and caregivers aligns with the notion of knowledge co-production, which views users as knowledge generators rather than merely knowledge recipients and encourages partnerships among people with different types of knowledge [48]. If robots are used in the long term, it will be important to design them to encourage ongoing knowledge co-production and dialogue between designers and caregivers. Robots can be used as a platform to improve robot developers' understanding and participation in care work, as well as to facilitate caregivers' effective involvement in customizing robots to suit older adults' needs.

6 Limitations and Future Work

Although we have presented a detailed analysis of selected studies, this review has notable limitations. First, it may not include all the relevant papers published before 2018 because, unlike the second stage, the first stage of paper screening did not follow a systematic review method. Second, the scope of this review is narrow. The ethical issues and design principles discussed may or may not be generalisable to home settings involving older adults or to other types of robots or care recipients. Third, the design guidelines are developed through a care ethics perspective and we focused only on ethical principles pertaining to care relationships and practices. These guidelines do not target specific ethical issues such as privacy and deception, which are commonly discussed in ethics related to robot care more generally [72]. We also acknowledge the challenges of implementing these guidelines in real-world contexts. Considering the complexity and diversity of people's needs in aged care contexts, we are not suggesting that designers should develop robots to meet the unique needs of every individual. Instead, we suggest that designers uphold the ethics of care when determining how robots can address the needs of users in aged care. Future work is required to test and expand these design guidelines in specific robot design studies.

7 Conclusion

This analysis comprehensively examined the literature on caregivers' and older adults' experiences with humanoid social robots in real-life residential aged care settings through the lens of Tronto's care ethics framework [65]. We found that robots may sometimes promote good care and at other times impede it. Care for older adults, we found, is delivered through a collaboration among caregivers, robots, and designers. We argued that robot design should prioritize the ethical elements outlined in Tronto's framework [65] and the CCVSD methodology [78] as they apply to the interconnected relationships among caregivers, robots, and designers. Robot design should facilitate successful collaboration among the three parties. Specifically, robots should assist caregivers in providing ethical care to residents, while designers should aim to provide ethical care to both older adults and caregivers. Thus, ethical care requires a cohesive partnership among designers, caregivers, and robots.

Based on the review, we presented four design guidelines essential to the ethical design of robots. These guidelines include addressing the needs of both older adults and caregivers, evaluating the cost-benefits of robots, considering the division of labour between caregivers and robots, and promoting the ongoing improvement and adaptation of robots to enable good care. These guidelines can help robot designers to translate care ethics [65] and the CCVSD methodology [78] into concrete design of social robots for aged care, thereby bridging the gap between theory and practice. By considering these guidelines, robot designers can contribute to improving the wellbeing of both older adults and their caregivers and promoting ethical care practices in aged care.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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References

1. Abbott R, Orr N, McGill P et al (2019) How do “robopets” impact the health and well-being of residents in care homes? A systematic review of qualitative and quantitative evidence. Int J Older People Nurs 14(3):e12239. https://doi.org/10.1111/opn.12239
2. Abdi J, Al-Hindawi A, Ng T et al (2018) Scoping review on the use of socially assistive robot technology in elderly care. BMJ Open 8(2):e018815. https://doi.org/10.1136/bmjopen-2017-018815
3. van Wynsberghe A, Li S (2019) A paradigm shift for robot ethics: from HRI to human–robot–system interaction (HRSI). Medicoleg Bioethics 9:11–21. https://doi.org/10.2147/MB.S160348
4. Amirova A, Rakhymbayeva N, Yadollahi E et al (2021) 10 years of human-NAO interaction research: a scoping review. Front Robot AI 8:744526. https://doi.org/10.3389/frobt.2021.744526
5. Andtfolk M, Nyholm L, Eide H et al (2021) Humanoid robots in the care of older persons: a scoping review. Assist Technol. https://doi.org/10.1081/10400435.2021.1881493
6. Barcaro R, Mazzoleni M, Virgili P (2018) Ethics of care and robot caregivers. Prolegomena Casopisza Filoz 17(1):72–81. https://doi.org/10.26362/20181204
7. Borenstein J, Arkin RC, Wagner AR (2022) A metaethical reflection: The ethics of embedding ethics into robots. In: 2022 IEEE International conference on advanced robotics and its social impacts (ARSO), pp 1–3. https://doi.org/10.1109/ARSO54254.2022.9812973
8. Broekens J, Heerink M, Rosendal H (2009) Assistive social robots in elderly care: a review. Gerontechnology 8(2):94–103
9. Caleb-Solly P, Dogramadzi S, Huijnen CAGJ et al (2018) Exploiting ability for human adaptation to facilitate improved human-robot interaction and acceptance. Inf Soc 34(3):153–165. https://doi.org/10.1081/01972243.2018.1444255
10. Carros F, Meurer J, L¨offler D, et al (2020) Exploring human-robot interaction with the elderly: results from a ten-week case study in a care home. In: Proceedings of the 2020 CHI conference on human factors in computing systems, Association for Computing Machinery, New York, NY, USA, CHI ’20, pp 1–12. https://doi.org/10.1145/3313831.3376402
11. Carros F, Schwaninger I, Preussner A, et al (2022) Care workers making use of robots: results of a three-month study on human-robot interaction within a care home. In: Proceedings of the 2022 CHI conference on human factors in computing systems, Association for Computing Machinery, New York, NY, USA, CHI ’22. https://doi.org/10.1145/3491102.3517435
12. Casey D, Barrett E, Kovacic T et al (2020) The perceptions of people with dementia and key stakeholders regarding the use and impact of the social robot MARIO. Int J Environ Res Public Health 17(22):8621. https://doi.org/10.3390/ijerph17228621
13. Cavenett W, Baker S, Waycott J, et al (2018) Deploying new technology in residential aged care: staff members’ perspectives. ACM, pp 200–204. https://doi.org/10.1145/3292147.3292214
14. Cheon E, Su NM (2016) Integrating roboticist values into a design framework for humanoid robots. In: The Eleventh ACM/IEEE international conference on human robot interaction, IEEE Press, Christchurch, New Zealand, HRI ’16, pp 603–604. https://doi.org/10.1109/HRI.2016.7451878
15. Coeckelbergh M (2015) Artificial agents, good care, and modernity. Theor Med Bioethics 36(4):265–278. https://doi.org/10.1007/s11017-015-9331-y
16. Coghlan S (2022) Robots and the possibility of humanistic care. Int J Soc Robot 14(10):2095–2108. https://doi.org/10.1007/s12369-021-00814-7
17. Coghlan S, Waycott J, Neves BB, et al (2018) Using robot pets instead of companion animals for older people: a case of ’reinventing the wheel’? In: Proceedings of the 30th Australian conference on computer-human interaction, Association for Computing Machinery, New York, NY, USA, OzCHI ’18, pp 172–183. https://doi.org/10.1145/3292147.3292176
18. Coghlan S, Vetere F, Waycott J et al (2019) Could Social robots make us kinder or crueller to humans and animals? Int J Soc Robot 11(5):741–751. https://doi.org/10.1007/s12369-019-00583-2
19. Coghlan S, Waycott J, Lazar A et al (2021) Dignity, autonomy, and style of company: dimensions older adults consider for robot companions. Proc ACM Hum Comput Interact 5(CSCW1):1–25. https://doi.org/10.1145/3449178
20. David K, Oliver B (2019) I am a Person: How value sensitive design can better support caring relationships for people with dementia, interpreted through the lens of personhood. ORBIT J 2(2):1–12. https://doi.org/10.29297/orbit.v2i2.80
21. Deci EL, Ryan RM (2012) Self-determination theory. SAGE Publications Ltd, New York, pp 1–1
22. Dudman J, Meyer J, Holman C et al (2018) Recognition of the complexity facing residential care homes: a practitioner inquiry. Prim Health Care Res Dev 19(6):584–590. https://doi.org/10.1017/S1463423618100105
23. Fiske A, Henningsen P, Buyx A (2019) Your robot therapist will see you now: ethical implications of embodied artificial intelligence in psychiatry, psychology, and psychotherapy. J Med Internet Res 21(5):e13216. https://doi.org/10.2196/13216
24. Ghafurian M, Hoey J, Dautenhahn K (2021) Social robots for the care of persons with dementia: a systematic review. ACM Trans Hum Robot Interact (THRI) 10(4):1–31. https://doi.org/10.1145/3469653
25. Gibelli F, Ricci G, Sirignano A et al (2021) The increasing centrality of robotic technology in the context of nursing care: bioethical implications analyzed through a scoping review approach. J Healthc Eng 2021:1–28. https://doi.org/10.1155/2021/1478125
26. Gilligan C (1982) In a different voice: psychological theory and women’s development. Harvard University Press
27. Hebesberger D, Koertner T, Gisinger C, et al (2016) Lessons learned from the deployment of a longterm autonomous robot as companion in physical therapy for older adults with dementia a mixed methods study, pp 27–34. https://doi.org/10.1109/HRI.2016.7451730
28. Hebesberger D, Koertner T, Gisinger C et al (2017) A long-term autonomous robot at a care hospital: a mixed methods study on social acceptance and experiences of staff and older adults. Int J Soc Robot 9(3):417–429. https://doi.org/10.1007/s12369-016-0391-6
29. Hewitt R (2021) Assistive care robots and older adults: employing a care ethics lens. Can J Bioethics Rev Can Bio´ethique 4(1):101–106. https://doi.org/10.7202/1078637ar
30. Hornecker E, Bischof A, Graf P, et al (2020) The interactive enactment of care technologies and its implications for human-robot-interaction in care, pp 1–11. https://doi.org/10.1145/3419249.3420103
31. Huisman C, Kort H (2019) Two-year use of care robot Zora in Dutch nursing homes: an evaluation study. Healthcare 7(1):31. https://doi.org/10.3390/healthcare7010031
32. Hung L, Liu C, Woldum E et al (2019) The benefits of and barriers to using a social robot PARO in care settings: a scoping review. BMC Geriatr 19(1):232. https://doi.org/10.1186/s12878-019-1244-6
33. Hung L, Wong J, Smith C et al (2022) Facilitators and barriers to using telepresence robots in aged care settings: a scoping review. J Rehabil Assist Technol Eng 9:20556683211072384. https://doi.org/10.1178/20556683211072385
34. Jaakola J (2021) Ethics by other means? Care robot trials as ethics-in-practice. TECNOSCIENZA Ital J Sci Technol Stud 11(2):53–72
35. Kadri A, Rapaport P, Livingston G et al (2018) Care workers, the unacknowledged persons in person-centred care: a secondary qualitative analysis of UK care home staff interviews. PLoS ONE 13(7):e0200031. https://doi.org/10.1372/journal.pone.0200031

36. Kanoh M, Oida Y, Nomura Y et al (2011) Examination of practicability of communication robotassisted activity program for elderly people. J Robot Mechatron 23(1):3
37. Kitwood TM, Kitwood T (1997) Dementia reconsidered: the person comes first, vol 20. Open University Press, Buckingham
38. Koh WQ, Ang FXH, Casey D (2021) Impacts of low-cost robotic pets for older adults and people with dementia: scoping review. JMIR Rehabil Assist Technol 8(1):e25340. https://doi.org/10.2196/25340
39. Lazar A, Thompson HJ, Piper AM, et al (2016) Rethinking the design of robotic pets for older adults. In: Proceedings of the 2016 ACM conference on designing interactive systems, Association for Computing Machinery, New York, NY, USA, DIS '16, p 1034–1046. https://doi.org/10.1145/2901800.29018112
40. Maslow AH (1954) Motivation and personality. Harper, New York
41. Melkas H, Hennala L, Pekkarinen S et al (2020) Impacts of robot implementation on care personnel and clients in elderly-care institutions. Int J Med Inform 134:104041. https://doi.org/10.1016/j.ijmedinf.2019.104041
42. Moher D, Shamseer L, Clarke M et al (2015) Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev 4(1):1. https://doi.org/10.1186/2046-4053-4-1
43. Moyle W (2019) The promise of technology in the future of dementia care. Nat Rev Neurol 15(6):353–359. https://doi.org/10.1038/s41582-019-0188-y
44. Mutlu B, Roy N, ˇSabanovi´c S (2016) Cognitive human-robot interaction. In: Siciliano B, Khatib O (eds) Springer handbook of robotics. Springer, Cham, pp 1907–1934
45. Nocentini O, Fiorini L, Acerbi G et al (2019) A survey of behavioral models for social robots. Robotics 8(3):54. https://doi.org/10.3390/robotics8130054
46. Noddings N (1984) Caring: a relational approach to ethics and moral education. Google Books University of California Press, Berkeley
47. Nomura T, Kanda T, Yamada S et al (2021) The effects of assistive walking robots for health care support on older persons: a preliminary field experiment in an elder care facility. Intell Serv Robot 14(1):25–32. https://doi.org/10.1007/s11370-020-00345-4
48. Norstr¨om AV, Cvitanovic C, L¨of MF et al (2020) Principles for knowledge co-production in sustainability research. Nat Sustain 3(3):182–190. https://doi.org/10.1038/s41893-019-0448-2
49. Obayashi K, Kodate N, Masuyama S (2020) Can connected technologies improve sleep quality and safety of older adults and caregivers? An evaluation study of sleep monitors and communicative robots at a residential care home in Japan. Technol Soc 62:101318. https://doi.org/10.1016/j.techsoc.2020.101318
50. Oppermann R, Rasher R (1997) Adaptability and adaptivity in learning systems. Knowl Transf 2:173–180
51. Osaka K, Sugimoto H, Tanioka T et al (2017) Characteristics of a transactive phenomenon in relationships among older adults with dementia, nurses as intermediaries, and communication robot. Intell Control Autom 08(02):16. https://doi.org/10.4236/ica.2017.82009
52. Osaka K, Tanioka T, Tanioka R, et al (2020) Effectiveness of care robots, and the intermediaries' role between and among care robots and older adults, pp 611–616. https://doi.org/10.1109/SII46433.2020.9026262
53. Papadopoulos I, Koulouglioti C, Ali S (2018) Views of nurses and other health and social care workers on the use of assistive humanoid and animal-like robots in health and social care: a scopingreview. Contemp Nurse 54(4–5):425–442. https://doi.org/10.1081/10376178.2018.1519374
54. Papadopoulos I, Koulouglioti C, Lazzarino R et al (2020) Enablers and barriers to the implementation of socially assistive humanoid robots in health and social care: a systematic review. BMJ Open 10(1):e033096. https://doi.org/10.1136/bmjopen-2019-033096
55. Persson M, Redmalm D, Iversen C (2022) Caregivers' use of robots and their effect on work environment–a scoping review. J Technol Hum Serv 40(3):251–278. https://doi.org/10.1145/3491102.3501956
56. Pfadenhauer M, Dukat C (2015) Robot caregiver or robot-supported caregiving? Int J Soc Robot 7(3):393–406. https://doi.org/10.1007/s12369-015-0284-0
57. Pols J (2015) Towards an empirical ethics in care: relations with technologies in health care. Med Health Care Philos 18(1):81–90. https://doi.org/10.1007/s11019-014-9582-9
58. Poulsen A, Burmeister OK (2019) Overcoming carer shortages with care robots: dynamic value trade-offs in run-time. Australas J Inf Syst. https://doi.org/10.3127/ajis.v23i0.1688
59. Sabelli AM, Kanda T, Hagita N (2011) A conversational robot in an elderly care center: an ethnographic study. In: Proceedings of the 6th international conference on human-robot interaction, Association for Computing Machinery, New York, NY, USA, HRI '11, pp 37–44. https://doi.org/10.1145/1957656.1957669
60. Saplacan D, Khaksar W, Torresen J (2021) On ethical challenges raised by care robots: a review of the existing regulatory-, theoretical-, and research gaps. In: 2021 IEEE International conference on advanced robotics and its social impacts (ARSO), pp 219–226. https://doi.org/10.1109/ARSO51874.2021.9542844
61. Sas C, Davies N, Clinch S, et al (2020) Supporting Stimulation needs in dementia care through wall-sized displays. In: Proceedings of the 2020 CHI conference on human factors in computing systems, Association for Computing Machinery, New York, NY, USA, CHI '20, pp 1–16. https://doi.org/10.1145/3313831.3376361
62. Sather R, Soufineyestani M, Khan A et al (2021) Use of humanoid robot in dementia care: a literature review. J Aging Sci 9:249
63. Shishehgar M, Kerr D, Blake J (2019) The effectiveness of various robotic technologies in assisting older adults. Health Inform J 25(3):892–918. https://doi.org/10.1178/1460458217829729
64. Santoni de Sio F, van Wynsberghe A (2016) When Should we use care robots? The natureof-activities approach. Sci Eng Ethics 22(6):1745–1760. https://doi.org/10.1007/s11948-015-9725-4
65. Tronto JC (1993) Moral boundaries: a political argument for an ethic of care. Psychology Press, London
66. Turja T, S¨arkikoski T, Koistinen P et al (2022) Basic human needs and robotization: how to make deployment of robots worthwhile for everyone? Technol Soc 68:101917. https://doi.org/10.1016/j.techsoc.2022.101917
67. Turkle S, Taggart W, Kidd CD et al (2006) Relational artifacts with children and elders: the complexities of cyber companionship. Connect Sci 18(4):347–361. https://doi.org/10.1081/09540090600868912
68. Unbehaun D, Aal K, Vaziri DD, et al (2020) Social technology appropriation in dementia: investigating the role of caregivers in engaging people with dementia with a videogame-based training system. In: Proceedings of the 2020 CHI conference on human factors in computing systems, Association for Computing Machinery, New York, NY, USA, CHI '20, pp 1–15. https://doi.org/10.1145/3313831.3376648
69. Vallor S (2011) Carebots and caregivers: sustaining the ethical ideal of care in the twenty-first century. Machine ethics and robot ethics. Routledge, New York, pp 137–154
70. van de Poel I (2021) Design for value change. Ethics Inf Technol 23(1):27–31. https://doi.org/10.1007/s10676-018-9461-9
71. Van Wynsberghe A (2016) Healthcare robots: ethics, design and implementation. Routledge, New York
72. Vandemeulebroucke T, Dierckx de Casterl´e B, Gastmans C (2018) The use of care robots in aged care: a systematic review of argument-based ethics literature. Arch Gerontol Geriatr 74(1):5–25. https://doi.org/10.1016/j.archger.2017.08.014

73. Vandemeulebroucke T, de Casterle BD, Gastmans C (2021) Socially assistive robots in aged care: ethical orientations beyond the care-romantic and technology-deterministic gaze. Sci Eng Ethics 27(2):17. https://doi.org/10.1007/s11948-021-00296-8
74. Wang X, Shen J, Chen Q (2022) How PARO can help older people in elderly care facilities: a systematic review of RCT. Int J Nurs Knowl 33(1):29–39. https://doi.org/10.1111/2047-3095.12327
75. Wang XV, Wang L (2021) A literature survey of the robotic technologies during the COVID-19 pandemic. J Manuf Syst 60:823–836. https://doi.org/10.1016/j.jmsy.2021.02.005
76. Waycott J, Kelly RM, Baker S, et al (2022) The role of staff in facilitating immersive virtual reality for enrichment in aged care: an ethic of care perspective. In: CHI conference on human factors in computing systems, pp 1–17. https://doi.org/10.1145/3491102.3501956
77. Wright J (2019) Robots vs migrants? Reconfiguring the future of Japanese institutional eldercare. Crit Asian Stud 51(3):331–354. https://doi.org/10.1081/14672725.2019.1612765
78. van Wynsberghe A (2013) Designing robots for care: care centered value-sensitive design. Sci Eng Ethics 19(2):407–433. https://doi.org/10.1007/s11948-011-9343-6
79. Yamazaki R, Kase H, Nishio S, et al (2019) A conversational robotic approach to dementia symptoms: measuring its effect on older adults. In: Association for computing machinery, Kyoto, Japan, pp 110–117. https://doi.org/10.1145/3349537.3351888
80. Yew GCK (2021) Trust in and ethical design of carebots: the case for ethics of care. Int J Soc Robot 13(4):629–645. https://doi.org/10.1007/s12369-020-00653-w
81. Yuan S, Coghlan S, Lederman R et al (2022) Social robots in Aged care: care staff experiences and perspectives on robot benefits and challenges. Proc ACM Hum Comput Interact 6(CSCW2):329:1-329:23. https://doi.org/10.1145/3555220
82. Zafrani O, Nimrod G (2019) Towards a holistic approach to studying human–robot interaction in later life. Gerontologist 59(1):e26–e36. https://doi.org/10.1093/geront/gny078

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