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Bachelor Thesis

Ethical Aspects of the Application of Social Robots in Elderly Care – A Scoping Review of Thematic Relevant Systematic Reviews

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Ethische Aspekte der Anwendung von sozialen Robotern in der Altenpflege – Ein Scoping Review thematisch relevanter Systematic Reviews

Submitted by:

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Abstract

Background: As demographic change and the shortage of caregivers create new challenges; social robots are being discussed as a possible solution. Social robots can improve well-being and promote independence and reduce loneliness through social interaction. Implementing new technologies in vulnerable groups requires consideration of ethical principles. The aim of this scoping review is to investigate the presence of ethical aspects in systematic reviews of social robots in elderly care.

Methods: A systematic literature search was conducted in the databases MEDLINE via PubMed, Scopus, and CINAHL via EBSCO. Systematic reviews were selected using eligibility criteria. Bibliographic information, population, social robots, and evidence gaps were described. Ethical aspects were grouped and analyzed thematically.

Results: 15 systematic reviews published between 2012 and 2022 were included. The majority (7/15) of the studies originated in Europe. Predominantly older people with cognitive impairments were included. There is no consensus on the definition of social robots. Ethical aspects are mentioned implicitly or explicitly in 13 systematic reviews. Ethical aspects were divided into the categories "beneficence and non-maleficence", "autonomy", "dignity and fairness" and "technological aspects".

Conclusions: Various ethical aspects are included in the systematic reviews but are often not discussed in depth. Aspects regarding autonomy are mentioned in most systematic reviews. Cultural differences in the perception of social robots should be investigated. When implementing social robots for older people, the context should be included holistically, and the human being should be put in the center. Ethical aspects should be considered in the research, application, and development of social robots. It is recommended that future studies include an ethical analysis.

Abstrakt

Hintergrund: Da der demografische Wandel und der Pflegekräftemangel neue Herausforderungen mit sich bringen, werden soziale Roboter als mögliche Lösung diskutiert. Soziale Roboter können mithilfe sozialer Interaktion das Wohlbefinden verbessern und Unabhängigkeit fördern sowie Einsamkeit verringern. Eine Implementierung neuer Technologien bei vulnerablen Gruppen erfordert die Berücksichtigung ethischer Prinzipien. Das Ziel dieses Scoping Reviews ist, das Vorhandensein von ethischen Aspekten in systematischen Reviews zu sozialen Robotern in der Altenpflege zu untersuchen.

Methode: Es wurde eine systematische Literatursuchen in den Datenbanken MEDLINE via PubMed, Scopus und CINAHL via EBSCO durchgeführt. Systematische Reviews wurden mithilfe von Auswahlkriterien ausgewählt. Bibliografische Informationen, die Population, soziale Roboter und Lücken in der Evidenz werden beschrieben. Ethische Aspekte wurden thematisch gruppiert und analysiert.

Ergebnisse: Es wurden 15 systematische Reviews eingeschlossen, die zwischen 2012 und 2022 publiziert wurden. Die Mehrheit (7/15) der Studien wurde in Europa erstellt. Es wurden überwiegend ältere Menschen mit kognitiven Beeinträchtigungen eingeschlossen. Bezüglich der Definition von sozialen Robotern besteht kein Konsens. Ethische Aspekte werden in 13 systematischen Reviews implizit oder explizit erwähnt und wurden in die Kategorien „Wohltätigkeit und Nicht-Schaden“, „Autonomie“, „Würde und Fairness“ sowie „technologische Aspekte“ geteilt.

Schlussfolgerungen: Verschiedene ethische Aspekte sind in den systematischen Reviews enthalten, werden aber häufig nicht tiefergehend diskutiert. Aspekte bezüglich der Autonomie werden in den meisten systematischen Reviews erwähnt. Kulturelle Unterschiede in der Wahrnehmung von sozialen Robotern sollten untersucht werden. Bei der Verwendung von sozialen Robotern für ältere Menschen sollte der Kontext ganzheitlich einbezogen werden und der Mensch in den Mittelpunkt gestellt werden. Ethische Aspekten sollten bei Forschung, Verwendung und Entwicklung von sozialen Robotern berücksichtigt werden. Es wird empfohlen, dass zukünftige Studien eine ethische Analyse beinhalten.

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List of abbreviations

ADL	Activities of Daily Living
AI	Artificial intelligence
AR	Assistive Robots
JBI	Joanna Briggs Institute
PRISMA-ScR	Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews
QoL	Quality of Life
RCT	Randomized Controlled Trial
RKI	Robert Koch Institute
SAR	Socially Assistive Robot
SAHR	Socially Assistive Humanoid Robots
SIR	Socially Interactive Robots
WHO	World Health Organisation

1. Introduction

The world population is aging. Between 2019 and 2050 the United Nations estimated that globally the number of persons aged 80 years or older will more than triple, increasing from 143 million to 426 million. As of 2019, 38 percent of European and Northern American residents are of the age of 80 and up (United Nations, Department of Economic and Social Affairs, Population Division, 2019, p. 18). The increase in older people is accompanied by an overall rising life expectancy: Due to improved living conditions, medical progress and effective care, more and more people are reaching old age (Rott & Jopp, 2012). These phenomena will lead to future challenges such as an increase in age-related diseases like dementia and consequently an increase in healthcare costs. Accordingly, there is a growing number of people that are dependent on others to take care of them – both in physical care and in social well-being. But opposed to the rising demand for resources and caregivers, the number of social and healthcare providers is decreasing. That is why different solutions are being sought to deal with these arising challenges.

One possible solution to assist care workers is robots. Robotics is a field that is increasingly becoming popular, and research is exponentially rising. Different kinds of robots can help with various tasks in taking care of the elderly. Robinson and colleagues classify healthcare robots into two different categories: rehabilitation robots and social robots. Rehabilitative robots are robots that support humans physically, either by helping the user with a task or by doing it for them (H. Robinson et al., 2014). A social robot can interact socially with its user. Therefore, it has the potential to improve loneliness and quality of life (Pu et al., 2019).

The last-mentioned aspects become even more important in times that are still influenced by the Covid-19 pandemic. Social robots might play a fundamental role in improving daily life. During the pandemic, older people have been the most vulnerable due to being at higher risk of complications in case of infection. Furthermore, elders have been severely affected by social distancing and lockdown measures and consequently have been one of the most isolated populations (European Commission, 2020, p. 2).

As elder care becomes one of the major challenges of the future and social robots have the potential to better cope with the consequences of demographic change, the topic is heavily studied in the literature and research. However, social robots remain an ethically charged topic. Therefore, the following bachelor thesis will address the ethical aspects of the application of social robots in elderly care.

2. Theoretical background

2.1 Definitions of social robots

There is no general agreement on the definition of social robots (Henschel et al., 2021, p. 11). In the following, an attempt to present various scientific definitions will be made.

Sarrica and colleagues point out that the majority of those attempting to define social robots acknowledge and discuss the lack of a widely recognized, reliable, and valid definition, as well as the difficulty of trying to define a social robot (Sarrica et al., 2020, p. 7). Although the definitions they studied were very heterogenous, some common features of social robots could be identified: Social robots are physically embodied agents that operate autonomously or semi-autonomously. Their bodies contain human- or animal-like features and the robots can engage in social interaction, for example, by responding to environmental cues. They can also have the ability to communicate, learn, make decisions or perform other tasks (Sarrica et al., 2020, p. 11).

Robinson and colleagues state that social robots are likable and easily understood interfaces that can act as a companion or help with certain tasks. Social robots can be categorized into companionship robots that aim to improve quality of life and service-type robots whose purpose is to assist its user. Some robots cannot be put into either category due to providing both companionship and assistance (H. Robinson et al., 2014). Some authors also include telepresence robots, as a new development in the field of robotics. They describe them as mobile socially assistive robots (SAR) with a videoconferencing function (Moyle et al., 2017). Whereas Kulpa and colleagues differentiate between three different domains of robots for their study: pet robots, social robots, and telepresence robots. They argue that telepresence robots do not possess autonomous behavior, as they need a remote user to operate them (Kulpa et al., 2021).

Another related term to social robots is “socially assistive robots” (SAR). Moyle and colleagues (2017) critique as well, that inconsistencies in the terminology used within the literature about SAR are making it difficult to find definitions for researchers and users. Feil-Seifer and Mataric define SAR as the intersection of assistive robots (AR) and socially interactive robots (SIR). The purpose of SAR is to assist human users through social interaction (Feil-Seifer & Mataric, 2005, p. 465). “Socially interactive robots” can be equated to social robots, both being able to engage in social interactions (Sandry, 2015; Li & Chignell, 2011 as cited in (Sarrica et al., 2020).

According to Moyle and colleagues, SAR is a subfield of robotics that encompasses various fields such as social and service robots, but also rehabilitation robotics, and human-robotic interaction (Moyle et al., 2017).

Another term that can be found in literature is “assistive social robots”. Assistive robots for the elderly can be categorized into two groups: assistive robotic devices like rehabilitation robots which are also “non social assistive robots” and the previously mentioned assistive social robots (Broekens et al., 2009; Heerink et al., 2010). Assistive social robots themselves can be divided into two subgroups service type robots and companion type robots. Service robots provide physical and cognitive assistance (Heerink et al., 2010, p. 362), for example, by supporting basic activities, mobility, household tasks, or health monitoring. Their social function is mostly existing to help the users interact with the robot. Companion type robots are often pet-like and mainly offer social support. In doing so, they have the potential to enhance health and psychological well-being (Broekens et al., 2009, p. 95).

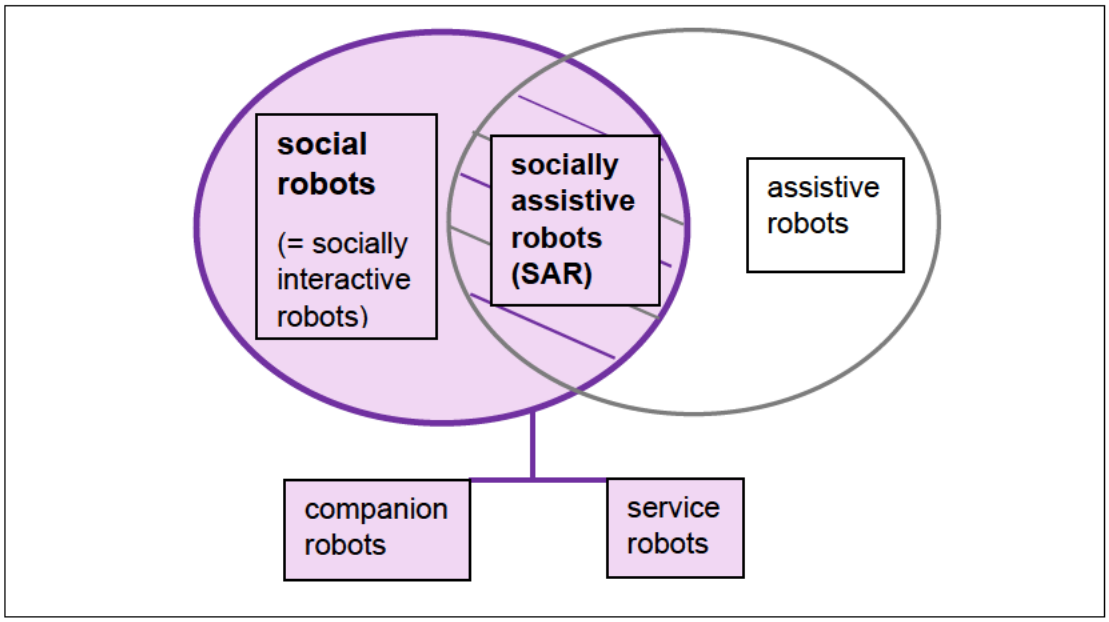

Figure 1: Definition of social robots (own illustration)

For this work, the author will concentrate on the term “social robots” and thus includes all robots that interact socially with its user. Moreover, Kachouie and colleagues argue that a complete separation of different types of robots is neither helpful nor possible because robots can often be assigned to several groups (Kachouie et al., 2014, p. 370).

2.2 Aging and social robots in elderly care

Being “old” is not a well-defined term. The beginning of the life phase “old age” is typically defined in parallel with the statutory retirement age of 65. Very old age is usually defined as being over the age of 80 or 85 (Rott & Jopp, 2012). Aging is a continuous process that takes place from conception to death. Different definitions distinguish between chronological, biological, and sociological age. Chronological age is the easiest to measure and describes the passage of time from birth onwards. Classifying individuals as “old” based on a specific number of years is a product of social history. Biological age describes the absence or presence of physical diseases, cognitive or functional impairment and therefore better reflects on health status than chronological age. The sociological age focuses on changing expectations and different roles that individuals adopt in society. The concept of successful and unsuccessful aging includes the possibility of positive developments in the aging process and explains the important effects that intrinsic factors and environmental effects can have on aging (Balcombe & Sinclair, 2001).

Aging is a highly complex process. To put it simple, molecular and cellular damage that accumulates over a lifetime can lead to age-related frailty and disease (Kirkwood, 2008). With advancing age, the likelihood of a decline in physical and cognitive performance and diseases, often with the resulting limitations in coping with daily life, increases. Consequently, the need for care and assistance can become a necessity. Becoming dependent on others in turn can restrict a self-determined lifestyle and put a burden on family members and society (Robert Koch-Institute, 2015, p. 409).

When getting older the risk for chronic diseases significantly increases. This can be especially problematic if multimorbidity is present. Physical diseases like cancer, diseases of the cardiovascular system, chronic lung diseases, or musculoskeletal diseases severely limit the quality of life. In addition, mental disorders such as depression have a significant impact on old age (Robert Koch-Institute, 2015). Dementia is the most common neuropsychiatric disease in elderly people. The prevalence of dementia in the general population varies greatly with age. While dementias occur very rarely before the age of 65, their prevalence and incidence increase exponentially after that age (Busch, 2011).

But even without pathological diseases, getting old is characterized by a loss of resources. Especially in very old age resources that are used for everyday tasks and challenges diminish. Resources include overall health status, cognitive performance (e.g., memory), social resources that are provided by spouses or friends, and education and occupational history as demographic resources (Rott & Jopp, 2012,

p. 475). In particular, declining social resources can lead to loneliness among the elderly which in turn promotes illness and reduces the quality of life (Yanguas et al., 2018).

When discussing care for the elderly, aspects like growing vulnerability with advancing age, but also existing and still developing potentials that occur during the aging process should be at the forefront. Health care should focus on restoring and maintaining independence while providing opportunities for the realization of self-responsibility, co-responsibility, and participation (Kruse et al., 2019).

The World Health Organisation (WHO) developed a framework for healthy aging. Healthy aging is defined as the process of building and sustaining functional ability that promotes well-being in older people, based on the two concepts of capacity and ability. Capacity describes the sum of all physical and mental capacities that is available to an individual at any time. Functional ability refers to the combination of an individual's intrinsic capacity, relevant environmental characteristics, and interaction between these characteristics and the individual. Therefore, healthy aging represents the continual interaction between individuals and the environment in which they live (Beard et al., 2016, p. 2149). Three subgroups of older people can be distinguished: those that have a high and stable capacity, individuals with a decline in function, and those that experience substantial loss of capacity. Goals should focus on improving losses that are related to higher age, but also, particularly on strengthening psychosocial growth and resilience (Beard et al., 2016, p. 2150).

The strong increase in the number of very old people due to demographic change shows the need to preserve and promote the resources of the elderly. The existing potential of primary prevention for this age group can be substantially expanded. Rott and Jopp stress the importance of psychological aspects as positive attitudes towards life and effective life management strategies appear to be capable of compensating for a wide range of physical impairments and limitations (Rott & Jopp, 2012).

This is where a social robot could offer an opportunity to engage in prevention and elderly care and to maintain and promote health. Social robots adopt different roles in elderly care: They can assist with physical tasks such as bathing, walking, or carrying objects, support cognitive function by playing memory games or setting reminders, and help with health management issues. For example, Robots can monitor blood pressure, encourage older people to exercise, and can be used to detect falls. Another application area for social robots is psychosocial issues where the robots provide entertainment and companionship (Broadbent, 2017, p. 629). Ghafurian and

colleagues categorized social robots based on the context for which the robot was developed and created five classes. The first class includes all robots that support users with **Activities of Daily Living** (ADL), e.g., preparing tea or washing hands. Robots that function as a **companion** are the second class. Those robots take on tasks like reminding the user about their medication or playing music or videos. Companion robots are distinguished from **engagement** robots. These robots increase the engagement of older people with others such as caregivers, family members, or other residents of care homes. The fourth class encompasses robots that give out **health guidance** by providing information about healthy living styles. The last identified class is robots that are used in the context of **therapy**. The social robots may be utilized as pets for pet therapy, they can assist the therapist or provide music (Ghafurian et al., 2021). Abdi and colleagues identified roles for socially assistive robots in health and social care which partly overlap with the classes that Ghafurian and colleagues formed. SAR can be applied in **affective therapy**, where the goal is to improve general mood and overcome episodes of mood disturbance, they can be used for **cognitive training** with the aim of improving aspects of cognition, and in **physiological therapy**, where the robots are supposed to have an effect on physiological markers. Another role that SAR take on is one of **companions**. These robots' aim is to overcome feelings of social isolation and loneliness. Similar to robots that Ghafurian et al. categorized as “engagement robots” Abdi and colleagues identified one role of SAR they named “**social facilitator**”. These robots act as a facilitator with the aim of improving sociability between the elderly user and other people (Abdi et al., 2018). The effects that social robots have on elderly people will be specified in the next chapter.

2.3 Impact of social robots on health

The scoping review of Abdi and colleagues suggests that social robots can have several positive effects on elderly people. Although social robots seem to be able to improve mood and overall sense of well-being, many studies suggest that in this regard SAR are not substantially more effective than similar soft toys or placebo robots. A significant difference between social robots and soft toys, however, was found in cognitive training. Those with healthy cognitive function provided the most convincing evidence that SAR can enhance cognitive performance. Robots that are used as social facilitators proved to be more effective than soft toys and improved sociability of users was shown in all included studies. A reduction in loneliness scores was found in all studies that included companionship robots. These positive findings,

however, might be confounded by the circumstance that some studies were conducted within a group setting. Positive findings of studies that researched effects on physiological markers were clinically uninterpretable. Abdi and colleagues concluded that the multidomain functionality of SAR might be its primary benefit, but also critiqued that the examined studies had several methodological issues (Abdi et al., 2018).

Pu and colleagues (2019) investigated the effectiveness of social robots for older adults and found out that the robots have the potential to reduce anxiety, agitation, and loneliness as well as medication consumption. The quality of life for older adults could be improved with the help of social robots. The effects on depression, cognition, and apathy did not yield any significant results and will need further research (Pu et al., 2019). Hirt and colleagues (2021) examined the effect of social robot intervention on people with dementia and differentiated between pet robots, humanoid robots, and telepresence robots. Pet robot intervention mostly included the social robot Paro and interventions were very heterogenous. There is no evidence to support the claim that social robot interventions improve dementia patients' cognitive status. Pet robots might have a positive effect on medication and apathy. Evidence for functional and emotional outcomes like quality of life was not clear enough to decide whether social robot interventions are beneficial or not. Studies on humanoid and telepresence robots were more rarely, hence, limited evidence exists (Hirt et al., 2021). Paro, the most known and researched social robot (Kulpa et al., 2021), may increase socialization and decrease aggression in people with dementia (Scoglio et al., 2019).

Outcome measures of studies about social robots are very heterogenous. Kulpa and colleagues (2021) argue that this shows the broad potential of social robots which has been recognized. They demand better evidence on the impact of social robots and cost-benefit comparisons, and how they affect the quality of life and functioning (Kulpa et al., 2021).

2.4 Ethical aspects of social robots

Ethics describes the theoretical reflection on the action-guiding convictions of individuals or groups of people with regard to the question of good or right behavior (Härle, 2018, p. 10). It refers to established standards of right and wrong that outline what people should do. These standards are typically expressed in terms of rights, certain virtues, obligations, or benefits to society (Velasquez et al., 1987).

As social robotics are a relevant topic in the future, ethical aspects are playing an important role in further considerations. Especially, if they are to be implemented in the care of vulnerable groups like the elderly. Nonetheless, only theoretical considerations of the ethical evaluation of social robots exist and no empirical studies that examined the extent to which the proposed ethical concepts were taken into account were found in a rapid review of 2022 (Zöllick et al., 2022).

Vandemeulebroucke and colleagues (2018) conducted a systematic review of argument-based ethics publications that focused on care robots used in aged care. They identified different ethical approaches, among them a deontological and a principlist approach. The **deontological** approaches included arguments about autonomy and dignity, deception as well as social isolation and connectedness. The **principlist** approach commonly consists of four principles, which are "respect for autonomy", "beneficence", "non-maleficence" and "justice". Arguments like the tension between autonomy and privacy, the importance of a transparent monitoring process, and a possible deception about the robots' capabilities are mentioned. Other aspects are the possible harm that robots could cause, the goal of promoting the overall well-being of the senior adults, how forming strong attachments to the robots can cause distress for the users and the risk of dehumanized care as well as social isolation. The principle of "justice" can also encompass the fair distribution of scarce resources and the open question of who takes responsibility when something goes wrong (Vandemeulebroucke, Dierckx de Casterlé, & Gastmans, 2018).

Schicktanz and Schweda (2021) argue that it is necessary to rethink the framing of technology-assisted eldercare: the bioethical principlism in healthcare needs to be expanded by ethical principles from engineering and computer science. These techno-ethical perspectives include aspects of technological empowerment, privacy, liability and responsibility, safety, and technological economization (Schicktanz & Schweda, 2021). Many of these arguments about care robots can also be transferred to social robots. For Feil-Seifer and Mataric (2011), the four principles of biomedical ethics are an appropriate starting point for considering ethical issues regarding socially assistive robots. Körtner (2016) developed different ethical guidelines for deploying social service robots. These guidelines concentrate on the aspects of deception, dignity, privacy, informed consent, safety, data protection, and vulnerability (Körtner, 2016). Some of these aspects will now be discussed in more detail.

Privacy describes the individual's right to independently determine the contact and closeness to others, that is, physical privacy, and the availability of information about

the own person, or informational privacy. There should never be a justification for entering someone else's private or intimate space without their will or their consent (Kruse, 2021, p. 220). Zöllick et al. (2022) emphasize the right of older persons not to be deceived or patronized. As social robots primarily affect the users through social interaction, older and vulnerable persons might imagine emotional capabilities in a robot that are not present. It was stated that it would be unethical if a machine was deceiving a person. The consequences of deception and anthropomorphization could be causing stress and developing false trust in a robot (Körtner, 2016). Additionally, emotional attachment could be formed to the social robots which can also lead to an ethical dilemma. As it is the aim of social robots to establish an enjoyable interaction between the robot and the user, engagement with the social robot is an essential part of achieving successful effects. But if the users are becoming attached, distress and perhaps loss of therapeutic achievements might occur when the robot is taken away, for example, because of technical malfunctions (Feil-Seifer & Mataric, 2011). Nevertheless, interacting with social robots has the potential for various health benefits, as mentioned earlier. Using social robots can lead to a reduction of subjective loneliness, increased engagement, communication, and social interaction, which in turn leads to less stress and improved mood (Zöllick et al., 2022). Safety is another ethical issue. Feil-Seifer and Mataric (2011) argue that since social robots primarily work through social interaction and are typically non-contact, the risk for physical harm is relatively low compared to robots that provide exclusively physical assistance. While social robots can act as a social facilitator, there is also concern that they reinforce social isolation of older adults and decrease real human contact (Körtner, 2016). Another aspect regarding autonomy is the opportunity to make informed decisions about the use of social robots. For this, it is essential to have full information about the capabilities of the social robot and be aware of one's biased perceptions of it. If the role of the robot is not clear, the robot's capabilities might be over- or underestimated. Necessary information must be made available to enable informed consent. In addition, the authority of the robot should be discussed, as a certain level of authority might be needed for the robotic intervention to be effective (Feil-Seifer & Mataric, 2011). Finally, the question of fair distribution and equal access is raised with regard to the costs of social robots, as well as who bears responsibility in the event of damage (Vandemeulebroucke, Dierckx de Casterlé, & Gastmans, 2018).

3. Objectives

To the knowledge of the author, no study investigated the presence of ethical aspects in systematic reviews about social robots in elderly care thus far. Hence, there is a need for a scoping review attempting to investigate whether existing literature with a focus on social robots in the context of elderly care includes an ethical discussion of their use. The purpose of this scoping review is to determine whether ethical issues surrounding the use of social robots in elder care are considered in the scientific literature, more precisely in systematic reviews. Based on what is already known from the literature presented earlier, the following research questions are formulated for this scoping review:

1) How are social robots **defined**?
2) What is the **purpose** of the social robots used in elder care?
3) Did the authors of systematic reviews discuss **ethical aspects**?
   If yes, which ones?
4) Are there any **evidence gaps**? If yes, what kind of evidence gaps?

As the field of social robots is still relatively new, it will be investigated how the study authors describe the robots and what terms they use to refer to them (e.g., social robot or SAR). Moreover, the purpose of the application of social robots will be examined. Since it is not well known whether ethical aspects play a significant part in scientific research on social robots used in elderly care, it will be evaluated if the authors explicitly or implicitly mention ethics, and what kind of aspects seem to be particularly relevant. Finally, existing gaps in research as well as emerging aspects for future applications will be discussed.

This scoping review will try to summarize ethical aspects in the context of social robots in elderly care discussed by the study authors as well as give an overview of the presence and consideration of ethics in current research about social robots.

4. Methods

To answer the research questions mentioned above, a scoping review according to the PRISMA-ScR guidelines (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) was conducted (Tricco et al., 2018). Scoping reviews are often used when a field of interest cannot be approached with a single or precise question, as the aim is to provide a map of the evidence. Their purpose is to identify knowledge gaps, key characteristics related to a certain concept

or types of available evidence in a specific field as well as to investigate the methods used in research on a certain subject (Munn et al., 2018). In general, an overview of existing evidence is provided without an assessment of the methodological quality of the included studies (Peters et al., 2015). A framework for the conduct of scoping reviews was developed by Arksey and O'Malley in 2005 and later enhanced by Levac and colleagues. The framework consists of six stages: The first stage is to identify the research questions which can be broad but should still define the population, concept and context. The purpose for conducting the scoping review should be clear. The second stages is the identification of relevant studies. Databases, search terms and filters such as time span and language should be determined. The available expertise and potential limitations are to be considered. Third, inclusion and exclusion criteria will be defined for study selection. The process of the study selection should be seen as iterative and at least two reviewers should screen the studies. For the fourth stage, the data charting, relevant variables that are to be extracted into a data charting form are determined. Then, the results are summarized, reported, and discussed in regard to the study's purpose as well as further implications for future practice, research and policy. The last stage, a consultation with stakeholders, is optional, but according to Levac and colleagues should be considered as an essential component of scoping reviews (Colquhoun et al., 2014; Levac et al., 2010). The Joanna Briggs Institute (JBI) also developed guidance for scoping reviews based on the framework of Arksey and O'Malley and Levac and colleagues which is consistent with the PRISMA-ScR guideline (Peters et al., 2015; Tricco et al., 2018). PRISMA-ScR is a reporting guideline with the aim of increasing the relevance of scoping reviews for decision-making as well as improving their reporting. It consists of 22 items (Tricco et al., 2018).

4.1 Search strategy and information sources

The systematic search to identify potentially relevant studies was conducted on 25 June 2022 in three literature databases. Chosen were the bibliographic databases MEDLINE via PubMed, CINAHL via EBSCO, and Scopus. MEDLINE via PubMed focuses on topics like biomedicine, health, and associated disciplines of health professions. It is updated daily and freely accessible. Scopus contains various thematic focal points, including natural, health, nursing, and social sciences as well as technology. Contrary to PubMed and Scopus, CINAHL is updated weekly and includes articles from scientific journals with a focus on nursing, medicine, and allied health literature. The search language for all three databases is English (Nordhausen & Hirt, 2020). For this reason, and the fact that most studies are published in English,

the search was conducted in the previously mentioned language. The search terms were developed by one researcher and no filters regarding publication date, language, or article type were set for the search. Keywords were searched for in the title and abstract and MeSH terms were used for the databases PubMed and CINAHL. Scopus has no subject heading system of its own, therefore only keywords were used. The search terms were developed using the PCC criteria (Population, Concept, Context): the population was the elderly and the concept social robots in any health-related context. To narrow down the search results, it was decided to focus on systematic reviews. The search terms were combined with the Boolean operators “AND” and “OR” and the asterisk (*) character was used to include different word endings. For example, the term “elder*” includes the terms “elderliness”, “elder”, “elders” and “elderly” (Kachouie et al., 2014). The search term was adapted to the database, respectively. A requirement of PubMed, for instance, is that one must use at least four characters for a wildcard search: the asterisk of “old*” would simply be ignored. The search string for PubMed is exemplified in Table 1. The search strategy for each database is presented in the Appendix (Table S1, S2, S3). If the full texts of selected articles were not available, authors were contacted via ResearchGate which thus supplemented the electronic database search as an additional information source.

Table 1: Search string in PubMed, 25.06.2022 (own illustration)

("social robot*"[Title/Abstract] OR "socially assistive robot*"[Title/Abstract] OR "social assistive robot*"[Title/Abstract] OR "socially interactive robot*" [Title/Abstract] OR "personal robot*"[Title/Abstract] OR "companion robot*"[Title/Abstract] OR "therapeutic robot*"[Title/Abstract] OR Paro[Title/Abstract]) OR (“Robotics*”[MeSH]) AND	
(aged [Title/Abstract] OR aging [Title/Abstract] OR older [Title/Abstract] OR elder* [Title/Abstract] OR "elderly people"[Title/Abstract] OR "old people" [Title/Abstract] OR "older people" [Title/Abstract] OR "older person*" [Title/Abstract] OR geriatric*[Title/Abstract] OR senior*[Title/Abstract] OR "senior citizen*"[Title/Abstract] OR "older adult*"[Title/Abstract] OR "old adult*" [Title/Abstract]) OR (“Aged”[MeSH]) AND	
("systematic review"[Title/Abstract]) OR ("Systematic Review" [Pulication type])	In total: **117**

4.2 Eligibility criteria

The eligibility criteria for included studies are based on the PCC criteria (see Table 2).

Table 2: summary of inclusion and exclusion criteria (own illustration)

Inclusion criteria	Exclusion criteria
(1) **P: Population**: Elderly humans	(1) Social robots for other populations
(2) **C: Concept**: Social robots or socially assistive robots	(2) Intervention without social robots or social robots not main focus
(3) **C: Context**: Any health-related context	(3) Technical outcomes or validation studies
(4) **Study type**: Systematic reviews	(4) Other study types than systematic reviews
(5) **Publication status**: Published in a peer-reviewed journal	(5) Another publication status
(6) **Publication language**: English or German	(6) Other languages than English or German
(7) **Access** to full-text studies selected for data coding	(7) No access to full-text studies selected for data coding

This work focuses on the population of the elderly. Systematic reviews that included older adults as well as different age groups, such as children or adolescents, or have not specified the age of the included population were excluded. The definition of "elderly humans" depends on the study authors, respectively. The concept is social robots or socially assistive robots, which must be the sole focus of the systematic reviews to be eligible, and not merely a part of the intervention. In this scoping review, social robots are defined as robots that interact with their user in a social context. This way, systematic reviews that did not explicitly refer to the robots as "social robots" also had the chance to be included. Studies could address any health-related context, such as acceptability, feasibility, usability, or application of social robots, different settings, and/ or outcomes (e.g., quality of life, efficacy for symptoms of depression, etc.).

The focus of this scoping review is on systematic reviews and other study types like primary studies, scoping reviews, narrative reviews, letters, protocols, and comments were excluded. To be included, articles had to clearly state, either in the title or in the methods, that it was a systematic review. Several reviews about social robots used by elders already exist. A scoping review of primary literature on social robots may not be necessary. Therefore, by focusing on systematic reviews, the aim is to avoid research waste (De Santis et al., 2022). Furthermore, the relevance of systematic reviews is higher compared to primary literature, as they contain a higher level of evidence and often serve as a basis for policy decisions and thus have a greater impact on society. It is therefore all the more important that systematic reviews also take ethical aspects into account.

Systematic reviews had to be published in a peer-reviewed journal in either German or English. Other literature like conference papers or abstracts, unpublished reports, books, theses, or articles that were not peer-reviewed yet were excluded. Finally, full texts of selected articles had to be accessible.

4.3 Selection process

The final search results from all three databases were added to the reference management software Citavi. In Citavi the duplicates were erased. The selection process was done in two screening phases using the eligibility criteria: the first screening phase regarded the title and abstract. Next, the considered studies were screened based on the full texts. Full text articles were assessed for eligibility if the studies seemed to meet the criteria based on title or abstract, or if the information from the title and abstract was not clear enough to exclude them. Both screenings were executed by the author of this work. Therefore, study selection was not carried out and discussed with another researcher, as is generally recommended.

4.4 Data extraction and synthesis of results

The data charting process will take place in a Microsoft Excel sheet and the following items will be coded:

- **Bibliographic information** (e.g., first author, year of publication, region of the corresponding author, funding sources, study aim)

- Information about the **primary studies** in Systematic Reviews (e.g., number of primary studies in the review, design of primary studies in the review, country of origin)
- **Population** (e.g., age, health status)
- Concept: **social robots** (e.g., robot type, definition used by authors, setting)
- Context (e.g., purpose of the robot)
- **Ethical aspects** (explicitly or implicitly mentioned? 4 principles: autonomy (*informed consent, privacy, data protection*), beneficence & non-maleficence (*safety, quality of life, emotional attachment, relationships, social isolation*), justice (*costs, fair distribution, responsibility & liability*)
- **Evidence gaps**

The “Results” section will include more information on this data. The data items were selected for their relevance to the research questions. The bibliographic information of the included studies will be described as well as the investigated population. It will be described how authors of systematic reviews define the included robots and which key characteristics are mentioned. The presence of ethical aspects will be described and identified ethical aspects in the systematic review will be summarized and grouped in thematic appropriate categories. To categorize the ethical arguments the author will concentrate on the principlist approach that will be expanded by techno-ethical aspects if necessary. Ethics that only concerning research methods and data collection were not considered as they were not part of the research question. The evidence will be presented in a narrative format and visualized through tables.

A quality assessment is not carried out, as it is not relevant to the research questions, because the consideration of ethical aspects is not dependent on the methodological quality of the studies. Furthermore, overlaps of primary studies within the systematic reviews are not examined. The potential to improve quality of life and well-being or other positive effects on health are not coded separately as an ethical aspect.

5. Results

5.1 Selection of sources of evidence

The different phases of the selection process are shown in Figure 2 in form of a flowchart which is based on the PRISMA statement (Moher et al., 2009). The systematic search found 117 articles from the database PubMed, 26 from Scopus and 59 from CINAHL. After removing the duplicates, 158 records were screened based

on title and abstract. In the title and abstract screening phase, the majority of studies were excluded because they did not do research on social robots. Instead, they studied robots in a medical context that, for example, assisted surgery processes or were used in rehabilitation for stroke therapy. Thus, n= 113 articles were excluded.

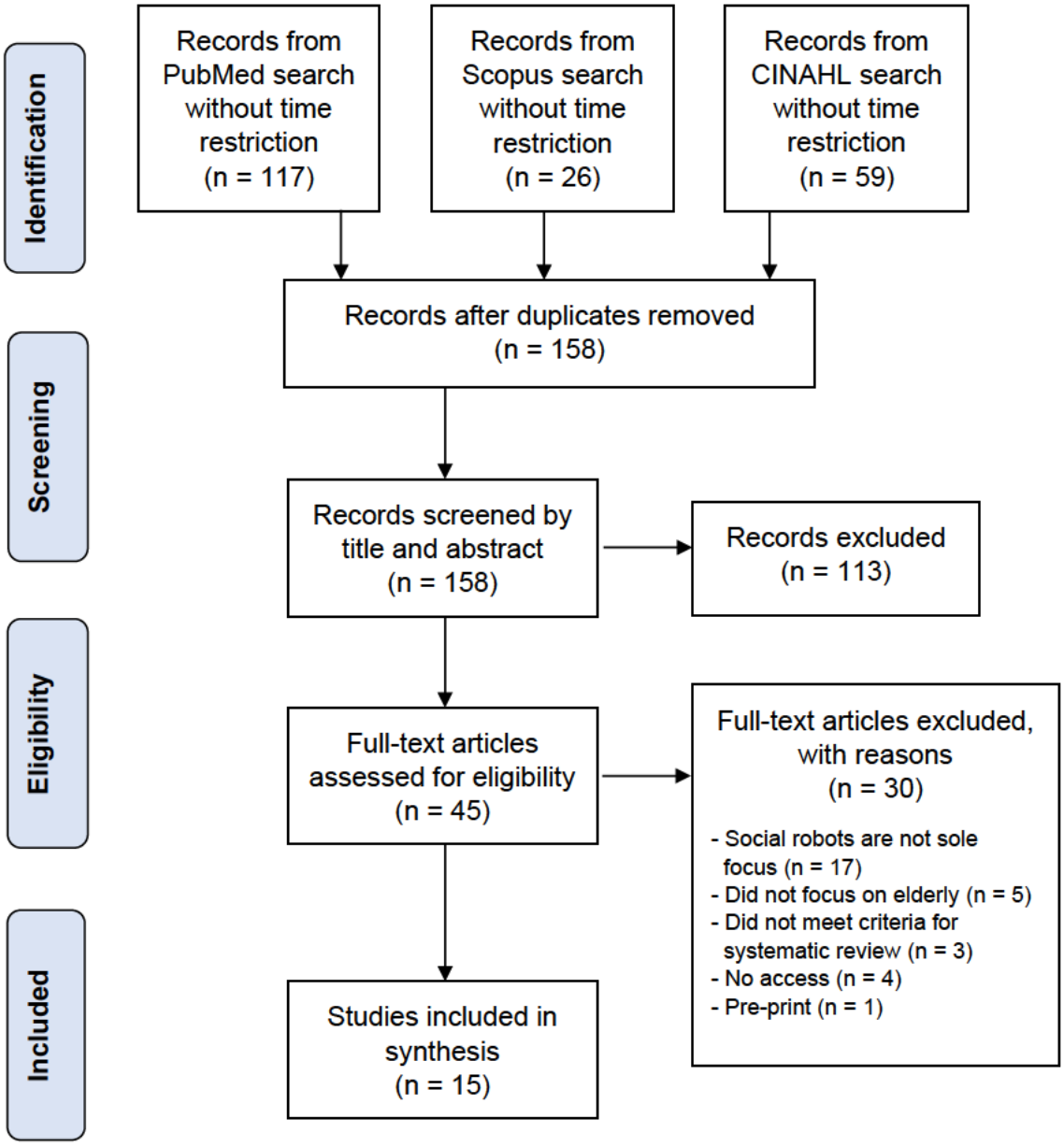

Figure 2: PRISMA flowchart (own illustration based on Moher et al., 2009)

In total, n= 45 articles were screened based on the full text. A reason for exclusion was that most studies did not focus on social robots as the only object of research, but rather included all types of robots (Pearce et al., 2012; Shishehgar et al., 2019), focused on telemedicine (Calvaresi et al., 2019; Narasimha et al., 2017), or interventions that only included social robots as part of the intervention (Aarskog et

al., 2019; Alnajjar et al., 2019; Jones et al., 2020; Loveys et al., 2022). Moreover, some studies did not primarily focus on older humans. Either the studies did not further specify the age of the included population (Riches et al., 2022; N. L. Robinson et al., 2019; Scoglio et al., 2019), or other age groups like children or adults were included, too (González-González et al., 2021). Three studies did not meet the criteria for a systematic review, either because it was a protocol (Chang & Sung, 2013), they did not explicitly mention that the study type was a systematic review in title or methods (Agnihotri & Gaur, 2016), or because it was a conference paper (Kachouie et al., 2017). Four articles were not accessible (Bedaf & Witte, 2017; Bemelmans et al., 2011; Clabaugh & Mataric, 2019; Kachaturoff et al., 2021). One study had just been published as a pre-print at the time of the search, which is why the criterion of a peer-reviewed article was not fulfilled (Lee et al., 2022). The complete list of excluded studies including the reasons can be found in the Appendix (Table S4). The 15 articles that met the inclusion criteria are described in more detail below.

5.2 Characteristics of systematic reviews

Bibliographic information

The included systematic reviews (n= 15) were published between 2012 and 2022, whereby the majority were published in the period from 2018 to 2022. Only two systematic reviews were from 2012 and 2014. Four systematic reviews also included a Meta-Analysis (Lu et al., 2021; Pu et al., 2019; Wang et al., 2022; Yu et al., 2022) The studies mostly originated from Europe (7/15) and Asia (4/15). In three systematic reviews, the corresponding author was from Australia. One study originated from North America. N= 10 systematic reviews reported no conflicts of interest, and altogether n= 7 studies received funding for their research. Three studies did not provide any information on conflict of interest or funding (Bemelmans et al., 2012; Chen et al., 2018; Kachouie et al., 2014).

The included primary studies in the systematic reviews ranged from seven to 66. Most systematic reviews included primary studies with any design. Only four studies focused exclusively on randomized controlled trials (RCT) (Kang et al., 2020; Lu et al., 2021; Pu et al., 2019; Wang et al., 2022). Most systematic reviews included primary studies that originated from at least three or more continents. In all studies where the information was available (n= 3 did not report the origin of all the included publications), studies from Europe and the United States were included. Most primary

studies coming out of Asia were conducted in Japan. No studies from Africa or South America were included.

Table 3: Characteristics of systematic reviews (own illustration)

Author, year	region corr. Author EU-Europe, AS- Asia, NAM-North America, AU-Australia	conflict of interest	funding	number of primary studies	primary studies: randomized controlled trials (RCTs)	primary studies: any design	origin of primary studies	Europe	North America	Asia	Australia	Oceania
Abbott et al., 2019	EU	no	✓	19		o		x	x		x	x
Bemelmans et al., 2012	EU	?	?	17		o		x	x	x		
Chen et al., 2018	AUS	?	?	7		o		x	x		x	x
Ghafurian et al., 2021	NAM	?	✓	53		o		x	x	x	x	x
Góngora Alonso et al., 2019	EU	no	✓	38		o						
Kachouoie et al., 2014	AUS	?	?	34		o		*n=19 from Japan*				
Kang et al., 2020	AS	no	✗	8	o			x	x		x	x
Lu et al., 2021	AS	no	✗	13	o			x	x		x	x
Papadopoulos et al., 2020	EU	no	✓	12		o		x	x	x	x	
Pu et al., 2019	AUS	no	✓	11	o			x	x	x	x	x
Vandemeule-broucke et al., 2018	EU	no	✗	17		o		x	x	x		x
Vandemeule-broucke et al., 2021	EU	no	✗	23		o		x	x	x		x
Vogan et al., 2020	AS	?	✓	11		o						
Wang et al., 2022	AS	no	✓	9	o			x	x		x	x
Yu et al., 2022	EU	no	✗	66		o		x	x	x	x	x

Description of population

All systematic reviews examined the elderly. Four systematic reviews additionally included other populations, such as informal caregivers and family, care home staff, and experts (Abbott et al., 2019; Ghafurian et al., 2021; Papadopoulos et al., 2020; Yu et al., 2022). The number of included participants varied greatly and was often not stated in the systematic reviews. N= 6 systematic review provided specific information about the age of the included population. Two reviews only included studies that examined adults that were 55 years old or older (Chen et al., 2018; Lu et al., 2021), which is why the age range for one systematic review was from 55 to 100 years (Chen et al., 2018). Vandemeulebroucke and colleagues (2018, 2021) defined the age of participants in the studies had to be 60 years or older. Alternatively, the mean age of participant groups had to be 60 years or older (Vandemeulebroucke et al., 2021) or 65 years or older (Vandemeulebroucke, Casterlé, & Gastmans, 2018), respectively. Another systematic review wanted to include older adults that were 59 years old or older; whereas the age range of older adults in the intervention studies was from 45 to 101 years (Vogan et al., 2020).

Five systematic reviews specifically targeted older adults with dementia (Ghafurian et al., 2021; Góngora Alonso et al., 2019; Kang et al., 2020; Lu et al., 2021; Yu et al., 2022). Furthermore, all the systematic reviews about social robots in elderly care included older adults that had some level of cognitive impairment. In most studies, the majority of participants experienced varying levels of dementia and cognitive impairment. Only Vandemeulebroucke and colleagues (2021) focused primarily on healthy older adults. Papadopoulos and colleagues (2020) did include participants with no or some degree of age-related cognitive impairment, but most participants were cognitively healthy. For three systematic reviews it could not be clearly determined how many of the primary studies focused on healthy older adults, as it was only known that healthy adults and those that suffered from different levels of cognitive deficits, or adults with or without cognitive impairment, were included (Ghafurian et al., 2021; Góngora Alonso et al., 2019; Vandemeulebroucke, Casterlé, & Gastmans, 2018).

Table 4: Description of population (own illustration)

Author, year	**population**: older adults	**other population** (e.g., informal/ formal caregivers)	**health status:** mostly healthy older adults	**health status:** majority has some level of cognitive impairment
Abbott et al., 2019	x	x		x
Bemelmans et al., 2012	x			x
Chen et al., 2018	x			x
Ghafurian et al., 2021	x	x	-	-
Góngora Alonso et al., 2019	x		-	-
Kachouie et al., 2014	x			x
Kang et al., 2020	x			x
Lu et al., 2021	x			x
Papadopoulos et al., 2020	x	x	x	
Pu et al., 2019	x			x
Vandemeulebroucke et al., 2018	x		-	-
Vandemeulebroucke et al., 2021	x		x	
Vogan et al., 2020	x			(x)
Wang et al., 2022	x			x
Yu et al., 2022	x	x		x

Description of social robots

The authors of the systematic reviews divided the robots into different categories: The majority focused on socially assistive robots (SAR) (n= 7). Additionally, one systematic review investigated "companion robots" which were defined as a subtype of SAR (Lu et al., 2021). Another review only included socially assistive humanoid robots (Papadopoulos et al., 2020). "Social robots" were assessed by four systematic reviews. Abbott and colleagues (2019) defined "robopets" or pet robots for their study and Wang et al. (2022) solely concentrated on the seal robot "Paro". How the authors of the systematic reviews defined the respective included robot is shown in Table 5.

A key aspect that is emphasized in the description of SAR by the systematic reviews is the ability to assist and help the user through social interaction. Being a social entity, physically present as well as able to act autonomously are also essential for SAR. In addition, the socially assistive robots communicate with their user, either verbally or nonverbally, and establish a close interaction. In doing so, they provide support and

companionship, promote well-being, and enable people to live independently. Papadopoulos et al. (2020) mention the use of artificial intelligence (AI). Definitions that concentrated on social robots were slightly more heterogenous, as they, for example, mentioned social behaviors and rules that the robots follow. Moreover, social robots engage their user in an interpersonal way, which can lead to the development of attachment. Having features that resemble humans or animals as well as the importance of social interaction is mentioned for both SAR and social robots. Abbott and colleagues specifically focused on pet robots which were described as "small animal-like robots" (Abbott et al., 2019). Two systematic reviews did not enclose a definition of the robot but instead focused on the robot "Paro", which is described as an interactive and social robot that provides companionship.

Table 5: Definitions of social robots according to study authors (own illustration)

Author, year	**Robot type**	**Definitions of robots** *(by study authors)*
Bemelmans et al., 2012	SAR	"Feil-Seifer et al. defined socially assistive robotics (SAR) as the **intersection of assistive robotics (AR) and SIR**." "(...), in SAR, these systems are not designed to help the human being performing work tasks or saving time in routine activities, but to **give assistance through social interaction** to achieve progress in, for example, convalescence, rehabilitation, and learning." (p. 115)
Góngora Alonso et al., 2019	SAR	selection criteria: the goal of the robot is the **improvement of support or social assistance** (p. 534)
Kachouie et al., 2014	SAR	"Any robot developed in this manner as a **social entity**, and possibly able to **communicate with users**, will fall into the category of social robots." (p. 369) " (…), but Feil-Seifer and Mataric (2005) described socially assistive robotics as the **meeting point of assistive robotics and socially interactive robotics** and stated that this kind of robot has the purpose of aiding humans **by emphasizing the importance of social interaction** in the process of providing specific assistance." (p. 369-370)
Vandemeule-broucke et al., 2018	SAR	"As a consequence, we characterize a SAR as a robot that has a certain degree of **autonomy** and an inherent **social capability**, ranging from a certain intentional bodily movement to fully developed social capacities, by which this robot can express itself while carrying out certain assistive functions." (p. 149)
Vandemeule-broucke et al., 2021	SAR	"Social robots are further divided into companion robots and socially assistive robots (SARs)." " (...), SARs are capable of combining **physical assistive** functions with **social interaction**." (p. 1) " (...), this meant that robots reported on had to be able to **vocally interact** with older adults and to be capable of making **autonomous bodily movements** and expressions, for example, presenting an appropriate facial expression or moving their arms. Studies on robots that solely had an assistive or social function were excluded." (p. 3)

Vogan et al., 2020	SAR or service-type robots	"A SAR is defined as an artificial agent possessing the features or **characteristics of either a human or an animal**. These robots are used to assist the elderly in **independent living activities**. The latter studies examined those robots with the main function of alleviating negative emotions and conditions, such as depression. Designed to serve the function of providing **companionship**, these robots resemble animals, such as cats, dogs and seals." (p. 18287)
Yu et al., 2022	SAR	"Socially assistive robots, however, are equipped with a **social interface** to enable **interaction** with the user and there are several subtypes." "There is no formal definition of a socially assistive robot, therefore we defined them as robots having a mechanical structure or design which **enables interaction** with a person with dementia to **promote their well-being**." (p. 2)
Lu et al., 2021	Companion robots as a sub-type of SAR	"Combining assistive robotics and socially interactive robotics, socially assistive robots (SARs) with audio, visual, and movement functions can **assist and interact** with individuals." (p. 2) "(...) SARs, which communicated or interacted with people by using sensors in the form of **verbal communication** (such as for humanoid robots), **nonverbal communication** (such as for pet-type robots), or both (...)" (p. 3)
Papadopoulos et al., 2020	socially assistive humanoid robots (SAHR)	"An advanced form of AI is the one used in socially assistive humanoid robots (SAHRs). These robots use gestures, speech, facial recognition, movements and, in general, **social interaction** to **assist** their users. The robot's goal is to create **close and effective interaction** with the human user for the purpose of giving assistance and achieving measurable progress in convalescence, rehabilitation, learning and well-being." (p. 1-2)
Chen et al., 2018	social robots	"A socially assistive robot is an **artificial intelligence system** designed to interact with humans by following **social behaviors and rules** attached to its role. Social robots, particularly animal robots, have beneficial effects similar to those of live animals, and these robots can elicit the same degree of **attachment** as a live dog." (p. 613)
Ghafurian et al., 2021	social robots	"In this review, we define a social robot as a robot that possesses **social skills** and is designed to interact with people in **human-centric terms** and to operate in human environments alongside people. Social robots engage people in an **interpersonal manner**, communicating and coordinating their behavior with humans through verbal, nonverbal, or affective modalities. Our criteria for considering a technology/machine a robot was (1) to have an embodiment and be physically present and (2) to be able to move and act upon its environment (...)." (p. 41:4)
Kang et al., 2020	social robot (Paro)	"The most popular companion robot for older adults with dementia is the social robot, **PARO**. Designed in Japan by Shibata, PARO is an **interactive** robot with five types of sensors: light, tactile, posture, temperature, and audio. PARO has been variously described as a companion robot, social robot, and seal robot." (p. 1)
Pu et al., 2019	social robots	"A social robot is defined as an **artificial agent** embodied with features of a **human or an animal**." (p. e38)
Abbott et al., 2019	pet robots	"Robopets were defined as **small animal-like robots** which have the appearance and behavioural characteristics of a companion animal or pet." (p. 3)

Wang et al., 2022	Paro	"The most popular companion robot for older adults is Paro, which has been variously described as companion robot, social robot, and seal robot." (p. 30)

The purpose of social robots that was mentioned the most was to improve the well-being and quality of life (QoL) of the users. The concept of "well-being" includes physiological functioning as well as psychological health. Another frequently stated purpose of the robots was to provide and enhance social interactions. That also encompasses the engagement of the users and the reduction of loneliness by providing companionship. The role social robots play in medication usage has also been investigated. Some systematic reviews stressed the aim of social robots to reduce symptoms of depression or dementia. In general, social robots provide assistance with daily living activities and help older adults maintain their independence. One study emphasized the use of social robots in cognitive training and affective therapy (Vogan et al., 2020).

Presence of ethical aspects in the systematic reviews

Regarding ethical aspects, it was examined whether the authors of the systematic reviews mentioned them explicitly or implicitly. N= 13 studies mentioned ethical arguments indirectly or directly. Two systematic reviews did not include any ethical statements (Chen et al., 2018; Kang et al., 2020), with the exception of possible positive effects of social robots. Most systematic reviews (n= 11) included ethical aspects of social robots at least implicitly, that is describing issues that can be assigned to different ethical arguments without calling them ethical. Some systematic reviews that explicitly mentioned ethical issues often demand the inclusion of an ethical discussion in future application of social robots, but without actually elaborating and discussing these aspects in further detail (Bemelmans et al., 2012; Pu et al., 2019; Wang et al., 2022). Ethical aspects that were mentioned in the systematic reviews are grouped and summarized below. Full author statements are listed in the Appendix (Table S9).

5.3 Ethical aspects in the systematic reviews

The data charting process identified several different ethical aspects regarding social robots in elderly care. These aspects were grouped into four different categories: beneficence and non-maleficence, autonomy, dignity and fairness as well as technological aspects (Table 6). Detailed statements of the authors can be found in the Appendix (Table S9).

Ethical aspects that were assigned to the category "**Beneficence and Non-maleficence**" focused in particular on the aspects of dehumanized care as a result of social robots and their effects as social facilitator. A major concern was the possibility that social robots could be used as a replacement for human care and interaction, and therefore worsen social isolation of older adults. The application of social robots in the area of, for example, ADLs could cause more neglect and fewer interactions with family caregivers (Ghafurian et al., 2021, p. 41:23). The reduction of real human contact was one of the main fears expressed by users, even though multiple systematic reviews stressed that replacing human interaction is not the objective of social robots (Abbott et al., 2019; Góngora Alonso et al., 2019; Pu et al., 2019; Vandemeulebroucke, Casterlé, & Gastmans, 2018; Vogan et al., 2020; Yu et al., 2022). However, Vogan and colleagues (2020) noted that this concern might not be unfounded, as the elderly population continues to grow in the future and pressure on health services increases, putting social robots at risk of being used as a substitute for social interaction, contrary to the recommendation (Vogan et al., 2020, p. 18298). According to Vandemeulebroucke and colleagues (2018), SARs might be considered suitable substitutes for human caregivers if they function as part of a safety system where they monitor older adults and notify health professionals in case of an emergency. Above all, they would be constantly available and primarily extend the care process (Vandemeulebroucke, Casterlé, & Gastmans, 2018, p. 158). It was found that most participants who had not interacted with social robots were concerned about a dehumanized society (Vandemeulebroucke, Casterlé, & Gastmans, 2018). Whereas Papadopoulos and colleagues (2020) and Vandemeulebroucke and colleagues (2018, 2021) addressed participants' concern of dehumanized care and society, Ghafurian and colleagues (2021) argued that this viewpoint is generally unjustifiable. Due to the positive effects social robots can have on the quality of life and well-being, such as decreasing stress and frustration, the robots could actually lessen relationship strain and therefore improve social interactions (Ghafurian et al., 2021, p. 41:23). Other systematic reviews have also highlighted the beneficial effects social robots can have on older adults. Social robots can increase engagement

(Abbott et al., 2019) and function as a facilitator for social interaction (Lu et al., 2021) and communication (Yu et al., 2022), which enables them to improve interaction among older adults and between older adults and their caregivers. Therefore, social robots can help older adults to live socially and reduce social vulnerability (Góngora Alonso et al., 2019, p. 538). Besides that, social robots provide pleasure, comfort, and companionship which can lead to a reduction in loneliness (Abbott et al., 2019).

However, in order to be effective and have a beneficial impact on older adults, the aim of social robots is to establish a relationship with its user. Other aspects that were often mentioned in the systematic reviews are emotional attachment to the robot and deception. Vandemeulebroucke and colleagues (2018) mentioned that the relationships that are formed with the robots were seen as counterfeit and thus, as deception (Vandemeulebroucke, Casterlé, & Gastmans, 2018, p. 162). It was described how convincingly the robots mimic social interaction between the robot and a human (Bemelmans et al., 2012). Over time, the relationship with the social robot may be perceived as a friendship (Papadopoulos et al., 2020, p. 9). Consequently, users can form an emotional attachment to the robots (Abbott et al., 2019; Vogan et al., 2020). Concerns that are related to the emotional attachment of the older adults to the robots may occur in the care of patients with dementia. Individuals whose cognitive abilities deteriorate with age may not understand what the social robot's actual capacities are. They will see the social robots as real companions and build a relationship with them, whereby the authors doubt their authenticity (Vogan et al., 2020, p. 18298). Forming emotional attachments to the robots seems to be negatively connoted, as it is also described as "excessive attachment (…) with detrimental effects" (Abbott et al., 2019, p. 17). Deception also seems to be seen as harmful, although Vandemeulebroucke and colleagues (2018) noted that in certain situations manipulations seem to be acceptable: To prevent harmful effects of the older individuals' behavior, interests of both professional and informal caregivers could be programmed into the robot (Vandemeulebroucke, Casterlé, & Gastmans, 2018, p. 163). Another aspect that was assigned to the category "beneficence and non-maleficence" was the possibility of social robots being a time burden for the staff (Yu et al., 2022).

The category of "**Autonomy**" encompasses aspects like the social robots' ability to enable older adults to live independently, and maintain or improve their independence (Ghafurian et al., 2021; Góngora Alonso et al., 2019; Yu et al., 2022). In addition, the importance of respecting older adults' rights and autonomy is emphasized by authors of systematic reviews. If an individual decides against the use of a social robot, for

example, because they are annoyed or bored by it (Abbott et al., 2019), their choice should be respected. Kachouie and colleagues (2014) stressed the importance of person-centered care and consequently the importance of respecting the choices of the elderly. Additionally, their life experiences and subjective perceptions should be valued. Some users express concerns that the robots might violate their autonomy (Vandemeulebroucke et al., 2021). Wand and colleagues (2022) emphasized the necessity to protect older people's rights when interacting with a social robot. For patients with dementia, it is more complicated to ensure informed consent: the individuals are incapacitated to varying degrees, so that an ethical participation in such an interaction is debatable (Vogan et al., 2020). To be able to make informed and self-determined decisions, it is also important to be informed about all the abilities and limitations of the robots, to prevent too high expectations (Papadopoulos et al., 2020). Another aspect is the discussion of who has the authority between the user and the robot. Vandemeulebroucke and colleagues (2018) reported that the relationship between the social robot and the user was seen as a boss-employee relationship with the robot being the employee. The user, therefore, had full control over the robot, but the robot still had some autonomous capabilities.

Ethical aspects in the category "**Dignity and Fairness**" included discussion points like equal access and discrimination. Six systematic reviews mention the aspects of the costs of social robots or other financial or economic issues (Abbott et al., 2019; Ghafurian et al., 2021; Vandemeulebroucke et al., 2021; Vandemeulebroucke, Casterlé, & Gastmans, 2018; Vogan et al., 2020; Yu et al., 2022). The question was raised whether everyone would have to chance to use a social robot, as they are cost-intensive. Not only purchasing, maintaining and programming would use up financial resources, but also potential training of clinical staff (Vogan et al., 2020). Furthermore, it was considered whether a financial investment directly into the care sector would not be more effective (Vandemeulebroucke, Casterlé, & Gastmans, 2018). Vandemeulebroucke and colleagues (2021) questioned the motivation with which social robots are used. Older adults felt that they were forced to be more receptive to the idea of social robots in elderly care, as they were an economic necessity. The robots were a sign of a society that was unwilling or unable to provide for its aging population (Vandemeulebroucke et al., 2021). Another ethical aspect that was discussed was the possibility of discrimination by the AI of the robots because of unconscious bias included in AI algorithms (Vogan et al., 2020, pp. 18299–18300). The ethical issue of infantilization is mentioned by four systematic reviews (Abbott et al., 2019; Vandemeulebroucke et al., 2021; Vandemeulebroucke, Casterlé, &

Gastmans, 2018; Yu et al., 2022). Older adults as well as professional staff were concerned about infantilization. Using social robots and losing some autonomy results in the inherent conflict of infantilization. Another concern of older adults was the risk of becoming a victim of ageism (Vandemeulebroucke et al., 2021, p. 11) or feeling the effects of stigmatism (Papadopoulos et al., 2020, p. 9). In general, Kachouie and colleagues (2014) stress the importance of seeing elderly people as a person and person-centered care that was inadequately represented in the primary studies.

Technological aspects included ethical issues like privacy, safety, and user-centeredness. Some studies mentioned safety concerns expressed by participants, for example in regard to technical malfunctions and/or technology limitations. Technical malfunctions could manifest themselves in form of an inconsistent behavior of the robot or the provision of incorrect information to the older adult (Vandemeulebroucke, Casterlé, & Gastmans, 2018), and could possibly harm the user. But Bemelmans and colleagues (2012) argued that compared to the more physical type of care robots, intrinsic safety will be easier to ensure for social robots because those mostly affect the users through social interaction alone (Bemelmans et al., 2012, p. 117). Furthermore, social robots could improve safety for older adults by monitoring older adults. Although this leads to a conflict of safety versus privacy. The aspect of privacy was also mentioned multiple times in the systematic reviews (Ghafurian et al., 2021; Vandemeulebroucke et al., 2021; Vandemeulebroucke, Casterlé, & Gastmans, 2018; Yu et al., 2022), but not further discussed except for the demand of maintaining users' privacy. Vogan et al. (2020) described the robot Paro and explain that it can remember faces and respond to human voices as well as actively seek eye contact (Vogan et al., 2020, p. 18295). This can raise concerns about the way social robots collect and save private information. Additionally, the potential of abusing the collected data is mentioned, in particular in the medical insurance sector (Vogan et al., 2020, p. 18299). Technical malfunctions as well as perceiving the robots as cold and inhuman objects can cause distrust and a decrease in the enjoyment of using social robots so that it is unlikely to be used (Vandemeulebroucke, Casterlé, & Gastmans, 2018). Six systematic reviews contain aspects that concern the development of social robots. It was stressed that the older adults, as well as other involved persons, need to be included in the development and design process (Ghafurian et al., 2021), as well as in the process of the application and implementation of social robots (Papadopoulos et al., 2020, p. 10). Abbott and colleagues (2019) stress the importance of speaking with family members about previous experiences with pets as well as preferences, as some people might not

react favorably to robots (Abbott et al., 2019, p. 20). Kachouie et al. (2014) emphasize the need to develop social robots from the viewpoint of the elderly and consider the expectation of various stakeholders like family members, nurses, and managers of nursing homes (Kachouie et al., 2014, p. 386). However, it was criticized that so far little consideration was given to the social environment when designing social robots (Góngora Alonso et al., 2019). Yu and colleagues (2022) noted that the acceptance of some social robots may increase if they would be conceptualized and developed in a way that enables the users to maintain their independence instead of symbolizing an individual's declining abilities (Yu et al., 2022).

Table 6: Categorization of ethical aspects in the systematic reviews (own illustration)

Author	Beneficence and Non-Maleficence	Autonomy	Fairness & Dignity	Technological aspects
Abbott et al., 2019	positive effects, increased engagement; attachment, replacing human interaction	rejection of robots	costs infantilization	Including all stakeholders (family members)
Bemelmans et al., 2012	Deception (mimics social interaction)			safety
Chen et al., 2018	-	-	-	-
Ghafurian et al., 2021	QoL, decreasing stress, frustration - improving social interactions; neglect by family members, decreasing social contact	independence	costs	all stakeholders, privacy, security/ safety
Góngora Alonso et al., 2019	reduction of social vulnerability; replacing human care	independence		social environment not considered
Kachouie et al., 2014		respecting choices and experiences	importance of person-centred care	user-centeredness - development
Kang et al., 2020	-	-	-	-
Lu et al., 2021	facilitator für social interaction	importance of patients' rights		

Papadopoulos et al., 2020	expectations, deception emotional attachment, familiarisation	informed consent		development: all stakeholders, harm through malfunction
Pu et al., 2019	not replacing humans	respect for human rights and autonomy		
Vandemeule-broucke et al., 2018	improving loneliness, manipulation acceptable; replacement for humans, dehumanized society, social isolation, deception	authority - who is boss	financial issues, infantilisation	objects, cold-decrease enjoyment; distrust safety vs. privacy, harm through malfunctions
Vandemeule-broucke et al., 2021	social isolation, dehumanized care	violation of autonomy	What is the motivation of application, robots a necessity, forced openness, infantilization, victim of ageism	privacy, trust
Vogan et al., 2020	attachment, social neglect, deception, substitute for human care/real interaction		Costs, bias and discrimination by AI	privacy, data protection, technical requirements, information collection and abuse of data
Wang et al., 2022		protect the rights		
Yu et al., 2022	acceptable use, facilitator of communication, assisting; time burden, replacing real human interaction	independence instead of stigmatism	equality of access, infantilization	user-centered development, privacy, safety in monitoring

Evidence gaps in the systematic reviews

Most authors identified similar evidence gaps. Oftentimes further research was demanded. The need for more high-quality and rigorously designed studies, like RCTs, was identified (Bemelmans et al., 2012; Chen et al., 2018; Pu et al., 2019; Wang et al., 2022; Yu et al., 2022). Other authors focused on the request for studies with a longitudinal design that investigated long-term impact of social robots (Abbott et al., 2019; Ghafurian et al., 2021; Papadopoulos et al., 2020; Vandemeulebroucke et al., 2021; Vandemeulebroucke, Casterlé, & Gastmans, 2018). Besides long-term effects, contextual, environmental and cultural factors should also be observed (Ghafurian et al., 2021). Additionally, future studies should include larger population samples (Bemelmans et al., 2012; Kachouie et al., 2014; Vandemeulebroucke et al., 2021). There was a call for cross-cultural studies (Ghafurian et al., 2021; Kachouie et al., 2014), as a large part of studies were conducted in Japan (Bemelmans et al., 2012) which can lead to potential cultural differences. Furthermore, more studies that included different settings like home environment (Vogan et al., 2020), and different populations, such as healthy older adults (Wang et al., 2022) and other stakeholders (Kachouie et al., 2014) like the healthcare workforce (Papadopoulos et al., 2020) and caregivers (Yu et al., 2022) are needed. Additionally, Yu et al. (2022) demand studies that are conducted in middle- and low-income countries as all their included studies were from high-income countries. The research was often focused on the social robot Paro, so future studies should also concentrate on other robots to enable the possibility of generalisability (Kachouie et al., 2014; Kang et al., 2020). Different biases and methodological issues were criticized. Novelty effects were often ignored so that possible benefits of social robots could be attributed to curiosity and excitement due to the new technology (Abbott et al., 2019). The Hawthorne effect was also disregarded (Kachouie et al., 2014) and could lead to changes in behaviors as the participants knew that they were under investigation. Vandemeulebroucke et al. (2021) report that there often were more female participants than male ones and demand sex-balanced samples. Another request was more validated and standardized measures for the participants' emotional state (Kang et al., 2020) and a better comparison of research groups' results (Vandemeulebroucke et al., 2021). Chen and colleagues (2018) point out the importance of a carefully selected control group intervention (Chen et al., 2018) and Pu et al. (2019) want future studies to focus on the dose-response effects of social robots. There was a call for clear definitions of social robots that are consistently used in articles about robots (Lu et al., 2021).

6. Discussion

This scoping review showed the consideration of ethical aspects in systematic reviews about social robots in elderly care. N= 15 systematic reviews were examined and aspects regarding beneficence and non-maleficence, autonomy, fairness and dignity as well as technological aspects were identified.

6.1 Summary of evidence

The research questions that have been stated in the part “Objectives” have been answered in the results and will now be summarized. The first question was about how authors of systematic reviews defined social robots. It was found that there was no consistent definition, and the robot type of social robot was not clearly demarcated. Definitions of SAR and social robots did not show any significant differences, although definitions of SAR were more homogenous. Certain characteristics were identified, such as owning features of animals or humans and assisting the user through social interaction. The definition of SAR by Feil-Seifer and Mataric (2005) which defines the robot as the intersection of SIR and AR was mentioned in two systematic reviews. The purpose of social robots was not always easily identified. The main purposes of social robots are the improvement of QoL and well-being through the provision of companionship and assistance, the enhancement of social interaction and the promotion of independence. Ethical aspects were discussed in the majority of systematic reviews, only two studies did not mention any. However, the extent and depth of the discussion of ethical issues varied greatly. The identified author statements that included a discussion of ethical issues were summarized in form of a keyword and grouped into different categories. The categories were inspired by the four principles of biomedical ethics and complemented by technological aspects, as social robots are not primarily assigned to the topic of biomedicine. Evidence gaps were described. There is a need for more high-quality research that keeps bias as low as possible. Furthermore, research on different stakeholders is required and the impact of cultural differences on the perception of social robots and related ethical aspects should be examined.

This scoping review does not concentrate on the discussion of what defines good care, or which ethical aspects are the most relevant. It points out which ethical issues are included in systematic reviews about social robots in elderly care. It should be kept in mind that the majority of included systematic reviews (n= 7) originated in an European country which is why values and viewpoints from this region may be

particularly represented. Ethical issues assigned to the category “Autonomy” were included in the most systematic reviews (n= 11). Aspects concerning beneficence and non-maleficence, such as the dehumanization of care and the effect of social robots on social interaction were discussed more extensively. Ethical issues that were mentioned hardly at all in any systematic review were transparency, for example, of the monitoring process and who takes responsibility and liability in case of malfunctions or damage. Rarely discussed were issues regarding data security and data management: How is the handling of sensitive data? What data is recorded, and processed and how is access by external persons prevented? Many ethical aspects were mentioned superficially without further elaboration.

It should be considered how many of the discussed ethical issues are also deemed relevant in practice and the everyday application of social robots. For example, the aspect of deception seemed to be perceived as harmful. Yu et al. (2022), on the other hand, found out that deception was not a major limitation for stakeholders. As long as interventions were beneficial, they seemed to be okay with deceiving older adults; in this case, people with dementia (Yu et al., 2022). Vogan and colleagues (2020) criticized that older people experiencing cognitive decline may genuinely believe they have a relationship with a machine. The relationship could be considered unreal because social robots are incapable of experiencing feelings and therefore cannot reciprocate them. How relevant these circumstances are perceived by affected persons, i.e., older adults, was not mentioned. It is important to discuss these points with older adults. This scoping review also showed the conflict that existed regarding the effect social robots have on social interaction. On one hand, social robots can act as social facilitators and increase engagement and communication, on the other hand, they can result in further social isolation and possibly replace humans. The effect that social robots ultimately have depends on their application and the intention with which they are used. The intention should be clearly defined before implementation. Apart from the call for involvement and consultation of all stakeholders, the aspect of a potential time burden on caregivers was the only one that related to people other than older adults. Time burden can arise when additional training for proper handling of the robots is required or when the caregivers must be constantly present while the social robot is in use and thereupon do not have time to fulfill their tasks. A contrary argument would be that social robots increase independence so that caregivers would be free to complete different tasks or assist others requiring attention while the user works on tasks or the like by themselves. Consequently, the caregiver would have more time for tasks where their skills have

the greatest impact and do not spend time on rudimentary and repetitive tasks (Vogan et al., 2020).

6.2 Limitations

When interpreting the results, several limitations that are in this scoping review should be kept in mind. First, this scoping review was conducted according to the PRISMA-ScR Checklist. However, it did not adhere to the guideline in regard to prior registration of a protocol which is important to show the process of the scoping review transparently (Elm et al., 2019). It is possible that relevant systematic reviews were not found and therefore not included in this scoping review. To begin with, the term “systematic review” is not always clearly defined and used so studies that did not mention the term in title or abstract, later in methods, were excluded. The search terms did not include any specific names of social robots except for “Paro” as the most common and established social robot. Further, search terms regarding the population did not include any age-related diseases, such as dementia. Studies that solely addressed social robots for dementia patients and did not include the term “elderly” in any way were excluded. Furthermore, only three databases were searched. Engineering databases were not included as it was assumed that they did not focus on systematic reviews. Teleoperated or telepresence robots were not sought as a primary focus in this scoping review. They were not defined as social robots because of their need to be operated remotely, therefore not being autonomous, and missing inherent social capacities. Another limitation is the fact that it was not possible to have a second person screening the articles and coding the data. Hence, the subjectivity of the author has to be taken into account as well as the own bias in identifying ethical aspects. The systematic reviews were screened for ethical aspects that have already been mentioned in the literature, although it is possible that some aspects were overlooked or openness for new aspects was restricted.

In general, it is possible that systematic reviews were excluded that were not published in English or German or were published later than the search date. For example, one article was excluded as it was still a pre-print at the time of the literature search and thus, did not fulfill the inclusion criteria. Later, it was published in a peer-reviewed journal and would have been eligible (Lee et al., 2022). It needs to be kept in mind, that the included systematic reviews did not aim to discuss ethical aspects. Therefore, several ethical issues might have been discussed in the primary studies, but, as it was not relevant for the research question of the systematic reviews, ethical

aspects might not have been transferred to the systematic reviews. However, the consideration of ethical aspects in the application of new technology like social robots in vulnerable groups is important and should be included regardless.

This scoping review did not conduct an analysis of overlaps or quality assessment of included systematic reviews. The analysis of overlaps examines how many of the primary studies are included in more than one systematic review, thus generating an excessive overweight. It is likely that there is overlap in this scoping review because two systematic reviews by the same corresponding author that included primary studies from the same year were included (Vandemeulebroucke et al., 2021; Vandemeulebroucke, Casterlé, & Gastmans, 2018). Additionally, two studies primarily focused on the robot “Paro” (Kang et al., 2020; Wang et al., 2022). It can be argued that an analysis of overlaps as well as quality assessment is more crucial for the evaluation of effectiveness. However, since the research questions focus on the presence of ethical aspects, it was assumed that the lack of analysis of overlaps and quality assessment was not severe.

The general effectiveness of social robots in elderly care, whether robots were more effective in a group setting or when used individually, how exactly the social robots are applied in elderly care and the acceptance of social robots were not a thematic focus of this scoping review. Furthermore, ethics that only discussed the research process was not a focus. This work does not show the ratio of where the primary studies were coming from or if any countries dominated the research field so it was hard to estimate cultural bias. It was also challenging to evaluate what role the cultural background of the study authors played regarding the inclusion and assessment of specific ethical aspects. However, Principlism is considered global bioethics and gives a moral framework that is universally applicable and permits a systematic evaluation of the moral dilemma in biomedicine. Furthermore, it is recognized by morally dedicated individuals across all societies and cultures (Beauchamp & Rauprich, 2016). As ethical aspects in the systematic reviews were discussed in varying depth, it was hard to map the extent to which the respective authors included ethical aspects. Table S9 in the Appendix presents this in a more comprehensible way. It should be pointed out that ethical issues related to social robots have mainly been addressed from the perspective of the elderly and not from the perspective of others involved, such as family members or caregivers. However, it is essential to note that social robots never affect only one target group and that the social environment of elderly people should be considered in a holistic context.

It was noted that a systematic review that did not include primary studies with qualitative study characteristics automatically excluded a deep discussion of the ethics of the application of social robots in elderly care. If the commonly used questionnaires of quantitative studies did not give the opportunity to highlight ethical concerns, stakeholders could not provide their opinions about ethical discussion points (Vandemeulebroucke et al., 2021).

6.3 Implications for further research and practice

Social robots are a new topic, many of its technological approaches are still in their infancy and most published literature is very recent. Schicktanz & Schweda (2021) note that the early stages of technological development provide opportunities for guiding ethical reflection. Likewise, it is crucial to make sure that ethical principles are used while designing social robots and AI interventions because many interventions are still created without taking ethics into account (Papadopoulos et al., 2020).

In general, more high-quality research is needed to establish the positive and clear effects of social robots in elderly care (Pu et al., 2019). Furthermore, their optimal application should be researched, as it is claimed that robots that only provide non-physical, social support might not be cost-effective (Bedaf et al., 2015). It is also criticized that robots that do not assist in any physical way could be substituted by other types of intelligent systems that have lower costs and higher robustness (Ghafurian et al., 2021).

More research is needed that focused on the application of social robots in a home setting (Vandemeulebroucke et al., 2021), even though this is harder to supervise and study. When developing interventions with social robots for the elderly, the focus should be on patient-centered care (Lu et al., 2021). The interventions should be targeted at the individual (Abbott et al., 2019), but also the robots themselves should be user-friendly and personalizable (Ghafurian et al., 2021).

Consulting with family members (Abbott et al., 2019), and co-designing robots with other stakeholders (Ghafurian et al., 2021), such as social scientists, health professionals, and users (Góngora Alonso et al., 2019), is important for future implementation of social robots. Some authors suggest establishing training for homecare staff to enhance the positive impact of the robots (Abbott et al., 2019; Wang et al., 2022).

It was found out that most ethical concerns did not matter enough to be obstacles to successful implementation in the real world. Costs were mentioned as the only deterrent to purchasing a robot (Yu et al., 2022). Still, it is argued that any studies about social robots in elderly care should always include an ethical analysis. It is suggested to use Health Technology Assessments (HTAs) which can also provide insights into how the robots are experienced by older adults (Vandemeulebroucke et al., 2021). It is important to engage in dialogue with older adults and consider different levels of digital literacy.

7. Conclusion

This scoping review provided an overview of ethical aspects that existed in systematic reviews about social robots in elderly care. Most systematic reviews mentioned several ethical concerns and aspects regarding social robots but the level of detail in which the aspects were described and discussed varied greatly. Many mentioned ethical aspects but did not go into more detail or carried out an ethical evaluation. There is a need for clear definitions regarding the type of social robots as well as universal ethical guidelines for the application of social robots in elderly care.

Social robots have the potential to improve well-being, social interactions, and independence. According to the WHO framework of healthy aging, social robots can help to maintain capacity in old age by providing assistance. They can be applied in all three subgroups: elders with high and stable capacity, those with a decline in function, and older people who experience substantial loss of capacity. Consequently, they might be used in future elder care and therapy, especially since the percentage of elderly people will rise further and the shortage of healthcare workers will continue to exist. As social robots are a type of new technology, they will initially be available mainly to the wealthier people, although aging is not restricted to one socioeconomic class. Open questions like who takes responsibility in case of damage or injuries caused by social robots should be discussed. Furthermore, consideration should be given to a fair distribution of scarce resources and if social robots are the ideal solution for existing problems in the healthcare sector.

When regarding the application of social robots in elderly care, a holistic approach is important that also includes older adults and other involved stakeholders in all steps of the process. Interventions should be adapted to the individual's needs and ethical aspects should be considered and discussed in research, implementation, and development. An analysis of ethics in future studies is recommended.

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Appendix

Table S1: Search strategy: PubMed

Bubbles	Applied Search	Search terms	Number of studies
A	**Social Robotics**		
A1	Keywords	A1 ("social robot*"[Title/Abstract] OR "socially assistive robot*"[Title/Abstract] OR "social assistive robot*"[Title/Abstract] OR "socially interactive robot*" [Title/Abstract] OR "personal robot*"[Title/Abstract] OR "companion robot*"[Title/Abstract] OR "therapeutic robot*"[Title/Abstract] OR Paro[Title/Abstract])	783
A2	MeSH terms	A2 "Robotics*" [MeSH]	36,449
A1 OR A2			**36,869**
B	**elderly**		
B1	Keywords	B1 (aged [Title/Abstract] OR aging [Title/Abstract] OR older [Title/Abstract] OR elder* [Title/Abstract] OR "elderly people"[Title/Abstract] OR "old people" [Title/Abstract] OR "older people" [Title/Abstract] OR "older person*" [Title/Abstract] OR geriatric*[Title/Abstract] OR senior*[Title/Abstract] OR "senior citizen*"[Title/Abstract] OR "older adult*"[Title/Abstract] OR "old adult*" [Title/Abstract])	1,466,280
B2	MeSH terms	B2 "Aged" [MeSH]	3,403,539
B1 OR B2			**4,266,439**
C	**systematic review**		
C1	Keywords	C1 ("systematic review"[Title/Abstract])	230,335
C2	MeSH terms	C2 "Systematic Review" [Pulication type]	199,389
C1 OR C2			**261,537**

(A1 OR A2) AND (B1 OR B2)	8,432
(A1 OR A2) AND (B1 OR B2) AND (C1 OR C2)	**117**

Table S2: Search strategy: CINAHL

Bubbles	Applied Search	Search terms	Number of studies
A	**Social Robotics**		
A1	Keywords	A1 **TI** ("social robot*" OR "socially assistive robot*" OR "social assistive robot*" OR "socially interactive robot*" OR "personal robot*" OR "companion robot*" OR "therapeutic robot*" OR Paro) OR **AB** (("social robot*" OR "socially assistive robot*" OR "social assistive robot*" OR "socially interactive robot*" OR "personal robot*" OR "companion robot*" OR "therapeutic robot*" OR Paro)	396
A2	MeSH terms	A2 (MH "Robotics+")	8,93
A1 OR A2			**9,104**
B	**elderly**		
B1	Keywords	B1 **TI** (aged OR aging OR old* OR elder* OR "elderly people" OR "old people" OR "older people" OR "older person*" OR geriatric* OR senior* OR "senior citizen*" OR "older adult*" OR "old adult*") OR **AB** (aged OR aging OR old* OR elder* OR "elderly people" OR "old people" OR "older people" OR "older person*" OR geriatric* OR senior* OR "senior citizen*" OR "older adult*" OR "old adult*")	633,165
B2	MeSH terms	B2 (MH "Aged+")	917,427
B1 OR B2			**1,283,488**
C	**systematic review**		
C1	Keywords	C1 **TI** "systematic review" OR **AB** "systematic review"	111,080
C2	MeSH terms	C2 (MH "Systematic Review")	111,090
C1 OR C2			**161,548**

A AND B	1,837
A AND B AND C	**59**

Table S3: Search strategy: Scopus

Bubbles	Applied Search	Search terms	Number of studies
A	**Social Robotics**		
A1	Keywords	TITLE-ABS ("social robot*" OR "socially assistive robot*" OR "social assistive robot*" OR "socially interactive robot*" OR "personal robot*" OR "companion robot*" OR "therapeutic robot*" OR Paro)	**6,295**
B	**elderly**		
B1	Keywords	TITLE-ABS (aged OR aging OR old* OR elder* OR "elderly people" OR "old people" OR "older people" OR "older person*" OR geriatric* OR senior* OR "senior citizen*" OR "older adult*" OR "old adult*")	**3,832,491**
C	**systematic review**		
C1	Keywords	TITLE-ABS ("systematic review")	**278,331**

A AND B	1,090
A AND B AND C	**26**

Table S4: Excluded studies with reasons for exclusion

Social robot not sole focus
1. Aarskog, N. K., Hunskår, I., & Bruvik, F. (2019). Animal-Assisted Interventions With Dogs and Robotic Animals for Residents With Dementia in Nursing Homes: A Systematic Review. *Physical & Occupational Therapy in Geriatrics*, *37*(2), 77–93. https://doi.org/10.1080/02703181.2019.1613466
2. Alnajjar, F [Fady], Khalid, S [Sumayya], Vogan, A. A [Alistair A.], Shimoda, S., Nouchi, R., & Kawashima, R. (2019). Emerging Cognitive Intervention Technologies to Meet the Needs of an Aging Population: A Systematic Review. *Frontiers in Aging Neuroscience*, *11*, 1–15. https://doi.org/10.3389/fnagi.2019.00291
3. Bao, Z., & Landers, M. (2022). Non-pharmacological interventions for pain management in patients with dementia: A mixed-methods systematic review. *Journal of Clinical Nursing (John Wiley & Sons, Inc.)*, *31*(7/8), 1030–1040. https://doi.org/10.1111/jocn.15963
4. Bedaf, S., Gelderblom, G. J [Gert Jan], & Witte, L. de [Luc] (2015). Overview and Categorization of Robots Supporting Independent Living of Elderly People: What Activities Do They Support and How Far Have They Developed. *Assistive Technology : The Official Journal of RESNA*, *27*(2), 88–100. https://doi.org/10.1080/10400435.2014.978916
5. Calvaresi, D., Marinoni, M., Dragoni, A. F., Hilfiker, R., & Schumacher, M. (2019). Real-time multi-agent systems for telerehabilitation scenarios. *Artificial Intelligence in Medicine*, *96*, 217–231. https://doi.org/10.1016/j.artmed.2019.02.001

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7. Chan, D., Chan, L., Kuang, Y. M., Le, M., & Celler, B. (2021). Digital care technologies in people with dementia living in long-term care facilities to prevent falls and manage behavioural and psychological symptoms of dementia: A systematic review. *European Journal of Ageing.* Advance online publication. https://doi.org/10.1007/s10433-021-00627-5
8. Haubold, A.-K., Obst, L., & Bielefeldt, F. (2020). Introducing service robotics in inpatient geriatric care—A qualitative systematic review from a human resources perspective. *Gruppe. Interaktion. Organisation. Zeitschrift Fur Angewandte Organisationspsychologie*, *51*(3), 259–271. https://doi.org/10.1007/s11612-020-00523-z
9. Jones, C., Liu, F., Murfield, J., & Moyle, W. (2020). Effects of non-facilitated meaningful activities for people with dementia in long-term care facilities: A systematic review. *Geriatric Nursing (New York, N.Y.)*, *41*(6), 863–871. https://doi.org/10.1016/j.gerinurse.2020.06.001
10. Latikka, R., Rubio-Hernández, R., Lohan, E. S., Rantala, J., Nieto Fernández, F., Laitinen, A., & Oksanen, A. (2021). Older Adults' Loneliness, Social Isolation, and Physical Information and Communication Technology in the Era of Ambient Assisted Living: A Systematic Literature Review. *Journal of Medical Internet Research*, *23*(12), e28022. https://doi.org/10.2196/28022
11. Loveys, K., Prina, M., Axford, C., Domènec, Ò. R., Weng, W., Broadbent, E., Pujari, S., Jang, H., Han, Z. A., & Thiyagarajan, J. A. (2022). Artificial intelligence for older people receiving long-term care: A systematic review of acceptability and effectiveness studies. *The Lancet. Healthy Longevity*, *3*(4), e286-e297. https://doi.org/10.1016/S2666-7568(22)00034-4
12. Mancioppi, G., Fiorini, L., Timpano Sportiello, M., & Cavallo, F. (2019). Novel Technological Solutions for Assessment, Treatment, and Assistance in Mild Cognitive Impairment. *Frontiers in Neuroinformatics*, *13*, 58. https://doi.org/10.3389/fninf.2019.00058
13. Moyle, W., Arnautovska, U., Ownsworth, T., & Jones, C. (2017). Potential of telepresence robots to enhance social connectedness in older adults with dementia: an integrative review of feasibility. *International Psychogeriatrics*, *29*(12), 1951–1964. https://doi.org/10.1017/S1041610217001776
14. Narasimha, S., Madathil, K. C., Agnisarman, S., Rogers, H., Welch, B., Ashok, A., Nair, A., & McElligott, J. (2017). Designing Telemedicine Systems for Geriatric Patients: A Review of the Usability Studies. *Telemedicine Journal and E-Health : The Official Journal of the American Telemedicine Association*, *23*(6), 459–472. https://doi.org/10.1089/tmj.2016.0178
15. Pearce, A. J., Adair, B., Miller, K., Ozanne, E., Said, C., Santamaria, N., & Morris, M. E. (2012). Robotics to Enable Older Adults to Remain Living at Home. *Journal of Aging Research*, 1–10. https://doi.org/10.1155/2012/538169
16. Shishehgar, M., Kerr, D., & Blake, J. (2019). The effectiveness of various robotic technologies in assisting older adults. *Health Informatics Journal*, *25*(3), 892–918. https://doi.org/10.1177/1460458217729729
17. Vandemeulebroucke, T., Dierckx de Casterlé, B., & Gastmans, C. (2018). The use of care robots in aged care: A systematic review of argument-based ethics literature. *Archives of Gerontology and Geriatrics*, *74*, 15–25. https://doi.org/10.1016/j.archger.2017.08.014

Did not focus on elderly

1. González-González, C. S., Violant-Holz, V., & Gil-Iranzo, R. M. (2021). Social robots in hospitals: A systematic review. *Applied Sciences (Switzerland)*, *11*(13). https://doi.org/10.3390/app11135976
2. Robinson, N. L., Cottier, T. V., & Kavanagh, D. J. (2019). Psychosocial Health Interventions by Social Robots: Systematic Review of Randomized Controlled Trials. *Journal of Medical Internet Research*, *21*(5), e13203. https://doi.org/10.2196/13203

3. Scoglio, A. A., Reilly, E. D., Gorman, J. A., & Drebing, C. E. (2019). Use of Social Robots in Mental Health and Well-Being Research: Systematic Review. *Journal of Medical Internet Research*, *21*(7), e13322. https://doi.org/10.2196/13322
4. Støre, S. J., Beckman, L., & Jakobsson, N. (2022). The effect of robot interventions on sleep in adults: A systematic review and network meta-analysis. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine.* Advance online publication. https://doi.org/10.5664/jcsm.10022
5. Riches, S., Azevedo, L., Vora, A., Kaleva, I., Taylor, L., Guan, P., Jeyarajaguru, P., McIntosh, H., Petrou, C., Pisani, S., & Hammond, N. (2022). Therapeutic engagement in robot-assisted psychological interventions: A systematic review. *Clinical Psychology & Psychotherapy*, *29*(3), 857–873. https://doi.org/10.1002/cpp.2696

Did not meet criteria for systematic review

1. Agnihotri, R., & Gaur, S. (2016). Robotics: A new paradigm in geriatric healthcare. *Gerontechnology*, *15*(3), 146–161. https://doi.org/10.4017/gt.2016.15.3.004.00
2. Chang, Shu-min & Sung, Huei-Chuan Christina (2013). The effectiveness of seal-like robot therapy on mood and social interactions of older adults: a systematic review protocol. *JBI Database of Systematic Reviews and Implementation Reports*, *11*(10), 68–75. https://doi.org/10.11124/jbisrir-2013-914
3. Kachouie, R., Sedighadeli, S., & Abkenar, A. B. (2017). *The role of socially assistive robots in elderly wellbeing: A systematic review. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 10281*. Springer Verlag. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85021671104&doi=10.1007%2f978-3-319-57931-3_54&partnerID=40&md5=1dbd75967ae9c2e497aedc80b8d8c0f6 https://doi.org/10.1007/978-3-319-57931-3_54

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Table S5: Data extraction: bibliographic information

Author	Year	Titel	Region corresponding author	Conflict of interest / Funding sources	Study type	Study aim (author statement)
Abbott et al., 2019	2019	How do "robopets" impact the health and well-being of residents in care homes? A systematic review of qualitative and quantitative evidence	UK Europe	**no** conflict of interest / funded NIHR	SR	To bring together the evidence of the experiences of staff, residents and family members of interacting with robopets and the effects of robopets on the health and well-being of older people living in care homes.
Bemel-mans et al., 2012	2012	Socially Assistive Robots in Elderly Care: A Systematic Review into Effects and Effectiveness	the Netherlan ds Europe	NR	SR	The objective of this review was to assess the published effects and effectiveness of robot interventions aiming at social assistance in elderly care.
Chen et al., 2018	2018	Social Robots for Depression in Older Adults: A Systemic Review	Australia	NR	SR	The aim of this study was to systematically review the effect of social robot interventions on depression in older adults.
Ghafurian et al., 2021	2021	Social Robots for the Care of Persons with Dementia: A Systematic Review	Canada North America	NR / Partially funded by the Network for Aging Research at the University of Waterloo. Funding from the Canada 150 Research Chairs Program	SR	The purpose of this literature review is to identify (1) the tasks for which the assistive robots are developed to help persons with dementia, (2) the level of success for each task/robot, (3) the appearance and social/emotional capabilities of the existing assistive robots, and (4) directions for future work with the goal of developing new assistive robots or improving existing robots in a way that they can effectively assist persons with dementia and their caregivers.

Góngora Alonso et la., 2019	2019	Social Robots for People with Aging and Dementia: A Systematic Review of Literature	Spain Europe	**no** / Partially supported by the European Commission and the Ministry of Industry, Energy, and Tourism under the project AAL-20125036 named ‘‘WetakeCare: ICT-based Solution for (Self-) Management of Daily Living.’’	SR	The main aim of this article is to present a review of the existing research in the literature, referring to the use of social robots for people with dementia and/or aging.
Kachouie et al., 2014	2014	Socially Assistive Robots in Elderly Care: A Mixed-Method Systematic Literature Review	Australia	NR	SR	The aim of this systematic review is to present an integrated report on published studies about SAR in the context of elderly care, to enable scholars to realize what is already known (Levy& Ellis, 2006) and connect ongoing studies to superior dialogue in the literature (Cooper, 1984; Creswell, 2009; C. Marshall & Rossman, 2006).
Kang et al., 2020	2020	Review of outcome measures in PARO robot intervention studies for dementia care	South Korea Asia	**no**	SR	The aim of this study was to describe interventions for PARO, as well as the outcomes evaluated including outcome measures and found following use of PARO for older adults with dementia.
Lu et al., 2021	2021	Effectiveness of Companion Robot Care for Dementia: A Systematic Review and Meta-Analysis	Taiwan Asia	**no**	SR and Meta-Analysis	This study conducted a meta-analysis using intervention time to explore results, strengthen the evidence on this controversial topic, and provide clearer recommendations for the development of companion robots to achieve positive effects in dementia care.

Papadopoulos et al., 2020	2020	Enablers and barriers to the implementation of socially assistive humanoid robots in health and social care: a systematic review	UK Europe	no / This work was supported by CARESSES project (Horizon 2020, Grant Agreement ID: 737858)	SR	Our review aims to understand what the current enablers and barriers to the use and implementation of SAHRs are, and concentrates on articles that describe the actual use of SAHRs among older adults. The primary focus is on exploring and identifying the factors that might facilitate or hinder the implementation of SAHRs in health and social care for older adults.
Pu et al., 2019	2019	The Effectiveness of Social Robots for Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Studies	Australia	no / Supported by a PhD scholarship from Griffith University and the Chinese Scholarship Council (CSC)	SR and Meta-Analysis	This review aims to summarize the effectiveness of social robots on outcomes (psychological, physiological, quality of life, or medications) of older adults from randomized controlled trials (RCTs)
Vandemeulebroucke et al., 2018	2018	How do older adults experience and perceive socially assistive robots in aged care: a systematic review of qualitative evidence	Belgium Europe	no	SR	The aim of this review was to gain a better understanding of how older adults experience, perceive, think, and feel about the use of socially assistive robots (SARs) in aged care settings.
Vandemeulebroucke et al., 2021	2021	Older adults' experiences with and perceptions of the use of socially assistive robots in aged care: A systematic review of quantitative evidence	Belgium Europe	no	SR	To gain insight into common aspects of older adults' experiences with and perceptions of SAR use in aged care, the relevant quantitative research literature was reviewed and synthesized.

Vogan et al., 2020	2020	Robots, AI, and Cognitive Training in an Era of Mass Age-Related Cognitive Decline: A Systematic Review	United Arab Emirates Asia	NR / This work was supported by the Zayed Center for Health Science under Grant 31R178.	SR	The primary aim of this systematic review will be to examine the efficacy of HRI as an intervention for elderly individuals experiencing age-related cognitive decline and investigate the growing potential for AI to maximize the effect of cognitive training.
Wang et al., 2022	2022	How PARO can help older people in elderly care facilities: A systematic review of RCT	China Asia	no / This research received the funding from the Technology Innovation and application development special general project of Chongqing, China.	SR (+Meta-Analysis)	This review aims to systematically evaluate the effects of Paro on older adults and provide a stronger basis for the rational application of Paro in aged care facilities.
Yu et al., 2022	2022	Socially assistive robots for people with dementia: Systematic review and meta-analysis of feasibility, acceptability and the effect on cognition, neuropsychiatric symptoms and quality of life	UK Europe	no	SR and Meta-Analysis	The aim of the study is to review evidence about feasibility, acceptability and clinical effectiveness of socially assistive robots used for people with dementia.

Table S6: Data extraction: primary studies

Author	number of primary studies	primary studies: design	primary studies: design_quan	primary studies country	continents
Abbott et al., 2019	19 studies in 27 publications	10x qualitative 7x RCTs (9 articles) 2x mixed-methods studies with qualitative elements (in 8 articles)	any	5x United States 4x Australia Italy, New Zealand, Denmark, Finland, Germany, the Netherlands, Norway, Spain, Sweden	North America, Australia and Oceania, Europe

Bemelmans et al., 2012	17 studies in 41 publications	NR	any	Japan, Italy, United States	Asia, Europe, North America
Chen et al., 2018	7	6x RCTs 1x comparison study	quantitative	Australia, Denmark, New Zealand, Norway, United States	Australia and Oceania, Europe, North America
Ghafurian et al., 2021	53 articles	NR	any	16 countries: Australia, Austria, Canada, China, Denmark, France, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Poland, Spain, United Kingdom, and the United States	Australia and Oceania, North America, Europe, Asia
Kachouie et al., 2014	82 publications in 34 study groups	publications included journal articles, conference proceedings, extended abstracts	any	mostly Japan (n = 19)	mostly Japan
Kang et al., 2020	8	RCTs	quantitative: RCT	Australia, Spain, Norway, New Zealand, USA	Australia and Oceania, Europe, North America
Lu et al., 2021	7 in meta-analysis, 13 in qualitative synthesis	RCTs	RCT	Australia, Norway, New Zealand, Denmark, United States, the Netherlands, Spain	Australia and Oceania, Europe, North America

Papadopoulos et al., 2020	12	6x mixed-method, non-randomised user experience trials 2x pre-post experimental surveys 1x mixed method, longitudinal experience trial 2x post-experimental surveys 1x ethnographic study	any	European (Austria, UK, Netherlands, France), Israel, Australia, Japan, Canada, USA	Europe, Asia, Australia, North America
Pu et al., 2019	11 (13 publications)	RCTs cross-over studies, two-arm (parallel) trials, multiple-arm trials	quantitative: RCT	Denmark, Norway, New Zealand, United States, Australia, Japan, Spain	Europe, Australia and Oceania, North America, Asia
Vandemeulebroucke et al., 2018	17 studies in 23 publications (7 qualitative, 10 mixed methods)	journal articles, conference proceedings (reporting on primary, empirical research using qualitative or mixed-method approach) including "thought experiments"	qualitative, mixed-method	UK, Finnland, France, Austria, Hungary, the Netherlands, Canada, Japan, Sweden, Belgium, USA, New Zealand, Singapore	Europe, North America, Asia, Oceania
Vandemeulebroucke et al., 2021	23	10x quantitative approach 13x mixed-method approach	quantitative, mixed-methods	USA, Canada, France, the Netherlands, Austria, Hungary, Italy, Korea, Singapore, Taiwan, New Zealand	North America, Europe, Asia, Oceania

Vogan et al., 2020	11	RCT 4x, controlled study, observational study, randomized block design with pre-post test, Randomized trial, pilot study with pre-post design, qualitative usability study, experimental study	any	NR	NR
Wang et al., 2022	9	RCTs	quantitative: RCT	Australia, New Zealand, Norway, Spain, USA	Australia and Oceania, Europe, North America
Yu et al., 2022	66	Quantitative cross-sectional study, RCTs, interventinal studies/ observational studies, qualitative studies, mixed-method studies	any	Europe (Norway, Sweden, Netherland, Italy&UK&Ireland, Austria, Spain, Germany), Australia, New Zealand, Korea, US, Japan, Canada, Hong Kong, India,	Europe, Australia and Oceania, Asia, North America

Table S7: Data extraction: Population

Author	Population (who?)	P_number	P population age	P population health status	pre-dominantly dementia
Abbott et al., 2019	older residents in care homes, theirs families and carers and care home staff	over 800 residents	NR mean age for each study: Table 2	just over half of the studies focused on residents with dementia	x
Bemelmans et al., 2012	older adults in elderly care	Table 3 range: 3-32	NR age range for primary studies: Table 3	majority: dementia (different levels of severity); healthy/ high functioning/good cognition	x

Chen et al., 2018	older adults	395 (from n=18 to n=124)	adults ≥ 55 from 55 to 100 years	76% (=5 studies) people with dementia, 1 study: healthy women different levels of depression and severity of dementia	x
Ghafurian et al., 2021	Persons with dementia; PwD and their caregivers care staff	Table 1 range: 1-139	NR for every study, Table 1	dementia/ healthy adults/ different levels of cognitive deficits	?
Kachouie et al., 2014	older adultsmajority were women	Table 1range: 1-67	Table 1; varies vastly among included studies	wide range of diseases; most are experiencing different stages of dementia(Table 1)	X
Kang et al., 2020	older adults with dementia	from 18 to 415	NR	different stages of dementia (mild/moderate/severe) Table 2	only dementia X!
Lu et al., 2021	older adults with dementia mostly women	agitation: 105 robot group, 109 control depression: 90 robot intervention; 80 control QoL: 86 pet-type robot; 75 control	main participants had to be 55 years old or older details for each study: Table 1	various types of dementia; dementia unclear (n=2)	X!
Papadopoulos et al., 2020	older adults aged ≥ 60 years (n=307); care home staff (n=106), informal caregivers (n=7)	420 (mostly small sample sizes, only 1 study over n=100)	older adults aged ≥60 (11 out of 12 studies)	with no or some degree of age-related cognitive impairment	mostly cognitive healthy
Pu et al., 2019	older adults	1,042 (range from 18 to 415)	Table 1	80% diagnosed with dementia or cognitive impairment	X
Vandemeule-broucke et al., 2018	older adults	Table 3+4 range: 3-123	older adults aged 60 years and older; participants groups: mean age of 65 years or above range: 50-95 years	two studies mild cognitive impairment, normal cogition (n=2), normal or impaired cognition (n=3), remaining: unclear	?
Vandemeule-broucke et al., 2021	older adults women majority in 19 studies	1070 range from 6 to 234; in most n=46 or less	60 years or older 21 studies: range 62-96 years 2 studies: 59-82	Mostly healthy older adults (n=18), Healthy older adults+ mild cognitive impairment (n=2), no information (n=3)	mostly healthy

Vogan et al., 2020	older adults 2 studies: either older and youger; undergraduate students	Table 2 range: 10-85	59 years or older; range: 45 to 101 years	healthy older adults (n=5); age-related cognitive decline, from mild cognitive impariment to advanced dementia (n=6)	(x)
Wang et al., 2022	older adults in aged care facilities	Table 1 range: 18-455	Table 1	varying levels of dementia (n=6); with or without dementia (n=3)	x
Yu et al., 2022	people with dementia, family caregivers, staff and experts mostly females	1750 people with dementia 178 family caregivers 232 staff and experts	Table 2, 3, 4, 5, 6, 7	≥ 70% of participants had to have a diagnosis of dementia	x

Table S8: Data extraction: Social robots

Author	Social robot_purpose	Social robot_purpose keyword	Concept robot type	C specific robots	C_setting
Abbott et al., 2019	effects of robopets on health and well-being (including depression, agitation, loneliness and stress and quality of life), social interaction, engagement, physical function, behavioural symptoms, medication use and adverse events	well-being (physical, psychological) & QoL social interaction & engagement & loneliness medication use	pet robots	15 studies, 23 papers: Paro 1x JustoCat 1x NeCoRo 1x AIBO 1x CuDDler	care homes LTC
Bemelmans et al., 2012	e.g., positive psychological social effects, depression and mood improved, staff stress, encouraged communication, more social interaction, levels of attachment, loneliness, task performance	well-being social interaction & loneliness	socially assistive robots	Bandit (3 publications, 1 study) AIBO (4 publications 4 studies) Paro (30 publications, 8 studies) NeCoRo (2 publ. 2 studies) 1 unspecific robot	nursing homes, care house, day service center, group home, geriatric health care facility, LTC facility,

	improved (Table 3)				
Chen et al., 2018	depression	reducing symptoms of depression	social robots	Paro (5x) communication robot (1x), health-monitoring functions robot (1x)	6 of 7 studies: LTC facilities 1 study at home
Ghafurian et al., 2021	reducing symptoms of dementia: agitation, anxiety, depression, night-time behavior disturbance improve independence of PwDs and improve quality of life.	reducing symptoms of dementia Quality of Life independece in daily living	p. 41:4 social robots p. 41:3 assistive robots for dementia care	Paro most common (19 studies and 4 applications) Table 1: Brian, Ed, RAMCIP, Matilda, AIBO, PARO, Ryan, MARIO, Giraff, Pleo, Pepper, RobuLab, Bandit II, NAO, Palro, SCITOS, Sophie and Jack, Betty	nursing homes; home setting
Góngora Alonso et al., 2019	psychological and physiological improvement of the cognitive impairment in the elderly and allow them to become more independent. provide social support, assistance, independence	well being and improving symptoms of dementia social support assistance independence	SAR	pet robot 25% humanoid robot 16,67% SAR 33,33% Telepresence robot 25% Table 3	NR eldercare (care center)
Kachouie et al., 2014	to improve well-being of elderly people	well-being	SAR	AIBO, Bandit, Healthbot, iCat, Ifbot, Nodding Kabochan, Nabaztag, NeCoRo, PaPeRo, Paro, Pearl. Robovie,Wonder	mostly nursing home
Kang et al., 2020	quality of life, biological and physiological conditions and medical treatment	well-being & QoL social interaction medication use	social robot	Paro	nursing home; dementia daycare & home, LTCs, residential care facilities, Table 2

Lu et al., 2021	agitation outcomes, depression, QoL	depression QoL & well-being	companion robots as a subtype of SAR	mostlyParo; NAO	all lived in LTC facilties (including 2 dementia units, 1 psychogeriatric care unit, 1 hospital and rest home areas)
Papadopoulos et al., 2020	multiple roles in the care of older adults such as affective therapy and cognitive training. They could be beneficial in reducing anxiety, agitation, loneliness and improving quality of life, engagement and interaction.	QoLlonelinessso cial interaction and engagement	socially assistive humanoid robots	Care-o-bot, NAO (3x), Kompaï (2x), SCITOS robotic plattform, Matilda, Betty, Brian, Pepper, Robovie2	RCFs, smart environments or university laboratirues, private apartment, RCF + laboratory-> non in an acute healthcare setting
Pu et al., 2019	agitation, neuropsychiatric symptoms, anxiety, Depressive symptoms and apathy, cognitive level Quality of Life Engagement, social interaction, Loneliness physiological indicators, medication	QoL & well-being social interaction and engagement, medication use	social robots	Paro, (8x) AIBO, NAO, IrobiQ, Cafero	majority in LTC facilities; 1 study females from home settings; 1 study hospital and LTC; 1 study daycare centers and participants' homes
Vandemeule-broucke et al., 2018	support older adults in maintaining their independence and to minimize social isolation	independence social interaction (minimize isolation)	SAR	Nabaztag, Karotz, Kompai robot, no robot was used, Care-o-bot, Tangy, Shopping Assistant Robot, CompanionAble, iRobi, RobuLab, Pearl nursebot, Nexi MDS, NAO; Kobian, Prototype robot	institutionalized (2x) and community-dwelling (9x) settings; remaining unclear

Vandemeule-broucke et al., 2021	tasks performed: household tasks, personal care tasks, companionship tasks, communication tasks	assistance in daily life - independence companionship social interaction	SAR	Kompai robot, Personal Robot 2, NAO robot, Brian 2.1 robot, 7 studies used lesser-known SARs	12x independent living 2x institutionalized 1x institutionalized+ independent living 8x no information
Vogan et al., 2020	cognitive training, impact on cognition when used in therapy, companionship, role in affective therapy	cognitive training companionship therapy	SAR or service-type robots	Kabochan Nodding Communication robot, Silbot and Mero, NAO 2x, Paro 5x, ActiveMedia Peoplebot, Pepper	Table 2
Wang et al., 2022	improve older adults' well-being, physical, and mental health. Quality of Life, biopsychological conditions, reducing medical usage	well being (physical, mental health) QoL medication use	Paro	Paro	retirement home, nursing homes, residential care facility, long-term care homes, dementia day care centers, urban secure dementia units
Yu et al., 2022	SAR: effects on dementia outcomes (cognition, neuropsychiatric symptoms: agitation, anxiety, depression, apathy, Quality of Life)	reducing dementia symptoms	SAR	Paro, AIBO, Justocat, NeCoRo, Pleo, Hasbro Joy for all, FurReal Friends robot, Hybrid-face robots, Kabochan, Lugwid, Giraff, Vgo, Ed, 3DX robot, MARIO, Matilda/Betty/Sophie and Jack/Papero, Guide, NAO, Silbot, Pepper,Ourpuppet ELISA	mostly living in long-term care setting (e.g., nursing homes)

Table S9: Data extraction: Ethics

Author	Ethics yes/no	Ethics_author statements	Keywords
Abbott et al., 2019	yes, indirectly	"Residents could also display excessive **attachment** to the robopets with detrimental effects for the individual and for relationships with other residents." (p. 17) "... as the **cost** of Paro made it unlikely that some care homes could afford to have one at all." (p. 17) " Staff were concerned that using robopets may have evoked **feelings of infantilisation** for residents (...)." (p. 17) Positive experiences on resident loneliness; evidence of reduction in agitation (meta-analysis); increased interaction and **engagement** (narrative) (p. 19) "The qualitative evidence synthesis also suggests that robopets may not be for everyone, and could **annoy or bore** some residents, or even cause some to become over-attached—effects that were not captured in the quantitative evidence, but which have been highlighted by other researchers." (p. 20) "However, it is clear that not all people are likely to respond positively, so **consulting with family members** about preferences and history with pets is likely to be important." (p. 20) "Whilst robopets should not be considered a **replacement for human interaction**, there appears to be scope for using them as therapy for agitated or isolated residents." (p. 21)	attachment, costs, infantilisation, positive effects, increased engagement, not replacement for human interaction, rejection of robots (respect for autonomy), all stakeholders
Bemelmans et al., 2012	yes, explicitly	"Multimodel robot interfacing **convincingly mimics social interaction** between a human and robot. Given this type of interaction, for such applications system robustness, reliability, and **intrinsic safety will be easier** to achieve than for the more physical type of care robots." (p. 117) "Also, the possible legal and ethical questions need to be adressed when the potential effects of SARs in elderly persons become more clearly outlined." (p.120)	deception, safety easier for social robots than physical
Chen et al., 2018	no other than the possible positive potential to reduce depressive symptoms	NA	NA

Ghafurian et al., 2021	yes, indirectly Yes; more literature	"(...) some PwDs raised concerns about applications in the area of ADLs possibly leading to more **neglect and fewer interactions** with family caregivers (...)." (p. 41:23) "However, “dehumanizing care” is mostly argued to be unjustifiable. In fact, the goal of assistive technologies in the context of ADLs is to **improve independence** of PwDs and improve quality of life. That is to say, while decreasing interactions with caregivers might be a concern for PwDs, many positive consequences such as decreasing stress, relationship strain, and frustration are reported, which can actually **improve social interactions**." (p. 41:23) need to **co-design** assistive robots (people with dementia and their caregivers); **costs** (p. 41:24) "(...) future work would be beneficial to expand on the existing body of literature on the **ethical implications** and considerations for designing social robots, as well as to understand the **privacy and security concerns** and considerations that need to be taken into account for developing social robots that can successfully assist caregivers and PwDs, while being **safe and secure** and maintaining **users' privacy**." (p. 41:26)	neglect by family members, decreasing social contact (-isolation), positive: QoL, independence positive effects (decreasing stress and frustration)- improve social interactions, all stakeholders, costs privacy and security
Góngora Alonso et al., 2019	indirectly	beneficence: " (...) for older people to **live socially** and **independently** through **reduction of social vulnerability**." (p. 538) "In a majority projects, destined for robot design, although the explicit objective is **not to replace human aid with robotic aid,** there is **little consideration** of the social environment, in which the development of the robot takes place." (p. 539)	positive effects: independence, reduction of social vulnerability replacing human care (no consideration for social environment)
Kachouie et al., 2014	indirectly	giving attention to **person-centered care** (is missing in included studies) "Person-centered care requires gathering and making use of personal information in care and **seeing the elderly as a person**. Moreover, **respecting elderly choices** and employing their past life **experiences** and subjective perceptions are critical in person-centered care. In developing SAR, researchers should look at the world from the **viewpoint of the elderly**. (p. 386)	importance of person-centered care seeing as a person respecting the choices and experiences development with users!
Kang et al., 2020	no other than the possible positive effects	NA	NA
Lu et al., 2021	not really	"(...) pet-type robot care might be useful in group treatment processes or even as a method for facilitating interaction between patients with dementia and their caregivers and therapists." (p. 10) "(...), educational training (eg, having appropriate knowledge of patients' hobbies and respecting participants' rights) (...) must be considered before the initiation of pet-type robot interventions." (p. 12)	facilitator for social interaction importance of patients' rights

Papadopoulos et al., 2020	yes; implicitly and explicitly	"(...) a recent qualitative exploration among different stakeholders in the healthcare context revealed that ethical and legal challenges, the lack of interests from professionals and patients, and concerns related to the robot's appearance and robotic expectations were major barriers to their potential use." (p. 2) "(...) in one of these studies participants felt that not only over time ease of use would improve, but also that the relationship with the SAHR may turn into a friendship." (p. 9) "Two other studies elaborated on the negative views towards robots in terms of dehumanisation of care and society, and of stigmatising effects associated to being a dependent individual in decline." (p. 9) "Technology malfunction and/or technology limitations were reported as areas of concern (...)." (p. 10) "Surprisingly for the heavily regulated field of healthcare, the issues of safety, ethics and safe guarding were not identified in this review as significant implementation-related factors, even though nurses and healthcare workers have been raising these issues. Safety and ethical issues were reported as major concerns in previous systematic reviews, and it is imperative that future research investigates these issues and understands their implications. The field of social humanoid robots poses many ethical challenges especially because robots could be designed to assume different roles and for different purposes: from service robots assisting in concierge types jobs to companion robots. In agreement with Vandemeulebroucke et al, we believe that an ethical approach demands that all stakeholders should have a voice in the current debate, but also in the design of future technologies, their application and implementation." (p. 10) "(...) policy makers should work collaborative to ensure the ethical and safe implementation of robots." (p. 10)	expectation (deception, informed consent), familiarisation; deception, emotional attachment dehumanized care just a viewpoint? ageism Harm through malfunction development: all stakeholders framework for ethical values
Pu et al., 2019	Yes, explicitly	"Furthermore, ethical issues should be considered as HRI is not designed to replace human contact but regarded as a possible adjunct to HAI in the care of vulnerable older adults. Human rights and autonomy should be respected during the application of social robots as some individuals may prefer live animal interaction." (p. e49)	not to replace humans respect for human rights and autonomy
Vandemeule-broucke et al., 2018	yes, indirectly + explicitly	SARs as virtuals doctors that monitor older adults: "SARs could be made continuously available and could even be seen as suitable replacements for human caregivers." (p. 158) The user-SAR relationship was regarded as a boss–employee relationship, with the user – the older adult – being the boss. (...) This illustrates the belief of some older adults that SARs should have autonomous capabilities but also should remain under the control of users." (p. 160) "Technical malfunctions, such as inconsistencies in a SAR's behavior, providing incorrect information to the user, and producing incomprehensible speech, were considered as losing control over the SAR; which causes or could cause distrust of the robot and to feelings of uncertainty about whether they should use it again." (p. 160) "The lack of spontaneity made the SAR appear as a cold, inhuman object and might decrease the enjoyment that older adults would have of the robot over time." (p. 161) "The primary ethical concern that was expressed by mostly participants who reflected	replacement for humans positive effects: loneliness, authority- who is the boss malfunctions and harm (trust) cold objects-decrease enjoyment dehumanized society social isolation deception safety vs. Privacy; manipulation acceptable, infantilization

		on the use of SARs in aged care settings without having interacted with one, had to do with a profound fear for a dehumanized society with the introduction of SARs." (p. 162) "(...) there was an underlying fear among many that social isolation could be a consequence of introducing SARs in aged care." (p. 162) "A SAR with the purpose of satisfying a companionship role was seen by some as a form of deception, since such a relationship was thought of as being counterfeit." (p. 162) "This safety function was mostly equated with a monitoring function. As a consequence, many participants felt a tension between the notions of safety and privacy in SAR implementations." (p. 162) "This implies that a certain amount of manipulation of the user by the SAR could be acceptable, e.g. reminders to do something to promote a healthy lifestyle." (p. 163) "Infantilization of older adults is also a result of the inherent conflict between the use of SARs and the loss of some autonomy." (p. 163) + financial and economic issues	financial issues
Vandemeule-broucke et al., 2021	Yes	"Only two studies reported on privacy issues." (p. 7) "(...) it seems that one central aspect of this process was not, or only slightly, touched upon in the included studies, namely the ethical dimension of SAR use in an aged-care setting." (p. 11) "Nonetheless, Vandemeulebroucke et al. (2018) pointed out that older adults do have broader ethical reservations about SAR use than simply the issues of privacy and trust. These authors identified four main ethical reservations vis-a-vis` SAR use in aged care. First, older adults fear that the use of SARs could lead to dehumanized care and a dehumanized society, in general, in which social isolation of older adults will only worsen. Second, older adults worry about their privacy and autonomy being violated by SARs. Third, older adults worry about being infantilized or becoming a victim of ageism. Fourth, older adults worry about the motivation behind using SARs in aged care, viewing this technology as an economic necessity." (p. 11-12) "In both of these studies, SARs were perceived as the physical manifestation of a society that is unable, or unwilling, to care for its older population. Consequently, SARs were perceived as a “necessary evil” (Wu et al. 2016, p. 11). Because of this perception, older adults felt they had to be necessarily more open to the idea of using SARs in aged care." (p. 12)	privacy, trust social isolation and dehumanized care privacy and autonomy infantilization; vicitim of ageism motivation of usage? Economic reasons? Society unable to care forced to be open about robots - necessity
Vogan et al., 2020		Paro: "It can also respond to the human voice. Additionally, it remembers faces, learns actions to produce positive reactions from its users, and actively seeks eye-contact." (p. 18295) "Despite the proven and potential benefits of Artificial Intelligence and SARs as tools of intervention to mitigate the symptoms of age-related cognitive decline, there are a number of concerns which arise related to user attachment and social neglect, possible practitioner disinterest, the technical requirements of health service providers and the prohibitive costs of robots. Interventions for elderly individuals experiencing age-related cognitive decline necessarily means that subjects will lack various degrees of incapacitation that make ethical participation in such an interaction contentious. Put simply, participants may not understand the actual capacities of the machines they interact with." (p. 18298) "Clearly, human beings of an advanced age who suffer from cognitive decline will come to view SARs as real	privacy, data protection attachment, social neglect, technical requirements/ literacy, costs deception (dementia) - no real relationships substitute for human care should not replace information collection (context robots or studies?)

		companions. Because of this, they are capable of developing, at least in their minds, relationships with these machines. Consequently, attachment should be expected." (p. 18298) "(...) because of the engaging nature of SAR combined with overwhelming pressures we can expect on future health services, as elderly populations grow exponentially, these tools designed to meet the needs of this vulnerable people could be at risk of becoming a substitute for real social interaction." (p. 18298) "(...) SARs are not, in fact, designed to replace practitioners of cognitive intervention of the elderly, but more specifically to augment and extend their effect." (p. 18299) "(...) there are the various costs of not only purchasing, maintaining and the programming, but of also training if the general knowledge of the clinical staff fails to meet the requirements." (p. 18299) "(...) concern has been expressed in the public sphere regarding the ethics of information collection and the possible abuse or error as it pertains particularly to medical insurance coverage." (p. 18299) Bias and discriminatation by AI	bias and discrimination
Wang et al., 2022	yes, explicitly	"Moreover, as older adults with dementia lost part or all of their autonomy, ethical issues should be considered during the application of Paro as intervention methods. How to protect the rights of older adults when they interact with Paro is worth thinking deeply about." (p. 37)	respect the rights, autonomy
Yu et al., 2022	Yes	Paro being reported as childish, and time burden for stuff. (p. 4) "Humanoid companion robots appeared feasible and acceptable to people with dementia, caregivers, and staff, but cost and potential reduction of human contact were raised as concerns." (p. 13) "Similarly, Pepper and MARIO were perceived by caregivers and staff to be useful in facilitating communication and interactions, and assisting daily care activities, such as safety monitoring. But concerns that robots might replace real human interactions were raised as limitations in both studies." (p. 16) "Acceptability of homecare robots may improve if they are conceptualised as a benefit and a means for maintaining independence rather than as sign of a person’s deteriorating ability." (p. 20) "From our review, several ethical concerns were raised as limitations of robots use in dementia, including use of pet companion robots was infantilisation of people with dementia, intrusions on privacy from teleoperated communication robots and reduced human contacts by substituting from all types of robots. Cost of robots presented as a continual limitation throughout our findings, raising an ethical concern related to equality of access of robot use on people with different socio-economic status." (p. 20)	infantilization, time burden, acceptable, costs, social isolation, facilitator of communication assisting, safety in monitoring, independence instead of sigmatism - user-centered development, privacy, equality of access

Table S10: Evidence gaps

Author	Evidence gaps	Evidence gpas keyword
Abbott et al., 2019	Understanding more about their **long-term impact** and the implications for implementation is required before robopets could be considered for **routine use** with older adults in residential care. …or whether **novelty** confers some of the possible benefit. It is possible that the nature of interactions may change from those initially stimulated through **curiosity**, but whether these **reduce impact** or simply **change** it needs to be investigated.	long-term impact novelty effects (curiosity)
Bemelmans et al., 2012	Finally, the intended effects of the robot interventions must be demonstrated in **RCTs with large enough populations and duration**. (most research is done in Japan - potential cultural differences) The next step could be to **identify the social psychological needs** of care providers and caretakers and then develop care interventions targeting these needs with available SARs. - further research into **effects** and potential use of SAR - experimentally investigate the effects of interventions featuring SAR within real elderly care settings	RCTs with large populations and long enough duration, cultural differences? Identifiying sockial psychological needs of care providers, further research into effects
Chen et al., 2018	**further studies** are needed before recommendations can be formulated to guide healthcare professionals who provide care to older adults through social robot interventions, and this review highlights a number of areas where research is needed. In future research, the **control group intervention** should be carefully selected. p.620 Due to the diversity of interventions and low sample sizes, the evidence suggests the need for **rigorous and powered studies** that can allow meta- analysis	further studies carefully selected control group internvention, more meta-analysis: rigorous and powered studies
Ghafurian et al., 2021	**cross-cultural challenges and effects** should be studied further to better understand personalization approaches, investigating **long-term effects!** (p. 41:25) Gaps were identified, which emphasized the importance of (1) understanding long-term effects of social robots,(as well as contextual, environmental, and cultural factors) (2) **personalization** based on PwDs' emotional states and cultural backgrounds, (3) developing assistive robots in the context of ADLs, and (4) understanding the preferred appearance and functionalities for an assistive robot depending on the context. Also, future work will benefit from studies that replicate the existing results in other situations and settings and with other groups and people with different levels of dementia.	cross-cultural challenges and effects, long-term effects (contextual, environmental, cultural factors) personalization of robots, robots in the context of ADL, understanding preferred appearance
Góngora Alonso et al., 2019	to identify barriers for the acceptance of robots in people who do not present any indication of dementia	barriers for acceptance

Kachouie et al., 2014	there is a need to do some cross-cultural studies, engaging different types of robots and home-based field trials. + multilingual robots great advantageHowever, most of the included studies came up with inadequate understanding on stated and perceived expectations.Only a few studies included stakeholders other than the elderly. Different stakeholders (e.g., nurses, family members, managers of nursing homes) have different needs and their expectations of robots vary widely, and it is important to consider their perspectives (Broadbent et al., 2009), so one of the starting points should be identification and examination of various stakeholders' expectations (Sitte & Winzer, 2004). Many of the included studies are weak in terms of writing and reporting, which limits the reproducibility and repeatability of trials.Inadequacy from research methodology viewpoint - nearly all of them are uncontrolled trials - biasInnovative research strategies are needed to overcome these imperfections. In future research, there is a serious need for addressing methodological issues and conducting research more rigorously.	corss-cultural studies, different types of robots, home-based field trialsinclusion of different stakeholders, more innovative research strategies, addressing methodological issues (minimizing bias: novelty effect and Hawthorne effect; not long enough, low sample sizes) p. 387
Kang et al., 2020	There was inconsistency among the findings of studies. Inconsistent findings may reflect the differences in the clinical and demographic characteristics of the participants, facilitator training, level and duration of exposure to PARO, and measurement tools. It is advisable to screen the presence of neuropsychiatric symptoms by using NPI-Q.32 ...However, different measures were used to assess the effects of intervention on participants' emotional state and social interaction with PARO. There is a need to develop more validated or standardized measures in this area. More studies warrant a review of outcome measures, including socially assistive robots such as NeCoro, a catlike robot, and AIBO, the robotic dog. Conclusion: Furthermore, there is a strong need for a standardized training protocol for both proxy observation and facilitator for evaluating the effectiveness of PARO intervention.	more validated or standardized measures for emtional state and social interaction with the robot; also other social robots,
Lu et al., 2021	"assistive social robots" are not consistently and clearly defined in articles on robots. Some research designs were not robust, described the intervention process in insufficient detail, and used inadequate sample sizes. Heterogeneity existed among the studies in the meta-analysis...No precision tools have assessed the effects of SARs on (socio)psychological and physiological outcomes. More research is required to confirm the effect of SARs on (socio)psychological and physiological outcomes. Cultural factors and the use of different tools to diagnose dementia mean that dementia has different definitions. Additional research is required to experimentally investigate the effects of the duration of exposure featuring pet-type robotics within a variety of older people health care settings. In addition, educational training (eg, having appropriate knowledge of patients' hobbies and respecting participants' rights) and environmental factors (eg, paying attention to the influence of the physical environment and strengthening observation and listening skills) must be considered before the initiation of pet-type robot interventions. Further research is urgently required in the field of pet-type robots (AIBO, NeCoro, and Haptic Creature)	clear definition of the robots, more research needed to confirm effects, duration of exposure, consideration of environmental facotrs and educational training
Papadopoulos et al., 2020	The evidence is too scant to generalise these initial findings, and further research is needed to assess the impact of these, and other factors, onto SAHR's acceptance and implementation in health and social care. Furthermore, the research focus has currently been placed	further research, no discussion of the needs of the healthcare

	on understanding the acceptance of robots by adult users, but there is no discussion of the needs of the healthcare workforce on a professional level, and how these needs are being met by educational institutions, professional organisations, and employers. Longitudinal studies can provide the opportunity to investigate whether fear of using a new and unfamiliar technology, or losing interest in a new technology (diminishing novelty effect), are related to negative attitudes.	workforce, longitudinal studies,
Pu et al., 2019	Therefore, more research is needed to identify the relationship between the severity of dementia and responses from using social robots. There is still a lack of RCTs comparing the effectiveness of different dosages of the intervention, such as frequency and duration of the use of the social robot with older adults. Evidence from animal-assisted therapy (AAT) may provide some guidance regarding the dose–response effects of social robot interventions. ... Further research should focus on the dose–response effects as well as the duration of social robot intervention required to achieve positive outcomes.	more research to identify relationship between severity of dementia and responses from using social robots, more RCTs; focus on dose-response effects, duration of social robot intervention
Vandemeulebroucke et al., 2018	Further research should focus more on the complexity of using SARs in aged care, as well as the complexity of people's attitudes expressed toward them. Longitudinal research on attitudes and experiences of older adults can produce a clearer account of the evolution in actual experience and attitudes toward SARs. Following Finch and colleagues (2003) and Pols & Willems (2011) we also recommend an ethnographic approach to study the implementation, appropriation and use of SARs in aged care settings because of the holistic nature of this type of approach.	focus more on complexity, longitudinal research on attitudes and experiences, using an ethnographic approach
Vandemeulebroucke et al., 2021	More research is necessary to fully understand the meaning of these findings in the particular social context of aged-care assistance. When participants only interact with SARs during a very limited time, we need to be careful when interpreting positive attitudes towards SARs because of an effect of SARs being something new. Referring to anecdotal evidence, Sharkey and Sharkey (2012) warn that this effect can fade away. Additionally it can be questioned whether such a "newness effect" is enough of a solid basis to build a substantial relationship with a SAR, of any sort, upon. Most of the included studies involved more female than male participants. Several studies supported the notion that older adults' reactions to robots could be influenced by their gender, or that one or the other sex may tend to have a negative attitude toward robots. Based on these limitations, future studies on older adults' experiences and perceptions regarding SAR use in aged-care setting should use a longitudinal design in which participants can interact with SARs for a longer period. Moreover, larger participant samples and sex-balanced participant samples are needed. Finally, there is an urgent need to develop and psychometrically test a valid measurement instrument to facilitate comparisons of different research groups' results.	more research, novelty effect, more female than male participants, longitudinal design studies, larger participant samples, sex-balanced samples, develop valid measurement instrument for better comparison of research groups results
Vogan et al., 2020	Future research should focus on SARs in the home environment. Finally, this systematic review has acknowledged that the confidence to employ future strategies or to make confident generalizations based on the findings of this review are diminished by the heterogeneity of the study designs and objectives, robot design and function, and sample size and sample duration. While some studies used healthy participants, others included participants experiencing	research in home environment, generalizations are limited by heterogenitiy of studies

	advanced cognitive decline. To strengthen confidence in the findings, by improved reproducibility and generalizability, these elements will need to be addressed.	
Wang et al., 2022	On one hand more studies should focus on exploring the potential of Paro for healthy older adults. On the other hand, more RCTs are needed to verify the effectiveness of Paro on older adults with dementia. We need further research to explore the optimal intervention formats based on users' needs and desires to maximize the beneficial of Paro. The result of this study indicates that further research are needed to examine appropriate intervention frequency and duration as well as the effects of dosage of Paro intervention. More RCTs should be established for exploring the role of Paro in older adults without intellectual obstacle and the optimal intervention methods in helping older adults interacting with Paro.	potential for healthy older adults, more rigorously designed RCTs, research to identify optimal intervention format (frequency and duration), more RCTs
Yu et al., 2022	Future research should further investigate whether the level of human resemblance could be important in acceptability of humanoid companion robot. Although the only RCT found no evidence of benefits of neuropsychiatric symptoms and quality of life, higher quality RCT are needed. telepresence communication robots: Robot developers could improve interface designs to simplify using them, and future studies could consider examining time saved. Future research should investigate what limitations of robots would influence real world implementation. All studies were from high income countries and thus there is no evidence about low- and middle-income countries. Third, we did not find any outcomes for caregivers when assessing effectiveness. Fourth, most participants were care homes residents, so our findings are less generalizable to community-dwelling population. Future research should explore in greater detail what happens during interaction between the user, the robot and anyone else present. This might provide new insights into effectiveness and immediate benefits of robot use. Also many studies were predominately qualitative or small observational studies without control groups and used non-validated outcome instruments. Future studies should use high quality designs to establish further evidence with active control groups to find out if companion robots are as good as or superior to plush toys or real animals.	higher quality RCT needed, studies needed from low- and middle-income countries, assessing oucomes for caregivers,

Table S11: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (after Tricco et al., (2018))

Section	Item	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review	yes
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	I, II
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach	1-9
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives	10
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	no
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	13, 14
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as	11, 12

		the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	11, 12
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	14
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	14, 15
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	14, 15
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	no
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	15
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	15-17
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	17-23
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	no
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	24-30

Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Table 6
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	31-33
Limitations	20	Discuss the limitations of the scoping review process.	33-36
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	36
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review	37

Eidesstattliche Erklärung

Ich versichere, dass ich vorliegende Arbeit ohne fremde Hilfe selbständig verfasst und nur die angegebenen Hilfsmittel benutzt habe. Wörtlich oder dem Sinn nach aus anderen Werken entnommene Stellen sind unter Angabe der Quelle kenntlich gemacht.

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Hamburg, 30.08.2022