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Examining the use and outcomes of social robot interventions in medication processes - A scoping review

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Abstract

A safe medication process is a central part of clients' comprehensive care. The multistep process of delivering a medication from the social and healthcare field to the client includes ordering/prescribing, transcribing/ verifying, dispensing/ delivering, medication administering, as well as monitoring/ reporting. Research in social robots is important to further understand and improve safe and successful medication processes. The aim of this study was to examine the use of social robot interventions in medication processes and to identify outcomes associated with such interventions.

The method used was a scoping review proposed by Arksey and O'Malley (2005). To identify relevant literature, a systematic search from 2018 to 2024 of the PubMed, EBSCOhost, CINAHL, MEDLINE databases was conducted, complemented with a free search using Google Scholar and reference harvesting. The initial search was conducted in May 2023, and the final search was conducted in June 2024.

Of the 2095 studies screened, seven studies were included. Use of social robots was identified in interventions such as dispensing/ delivering, medication administering, as well as monitoring/ reporting. The results showed that social robots can effectively support medication adherence, assist with health management, and provide valuable companionship and reminders. Technical issues such as errors in recognizing medication intake, communication limitations, and user discomfort were also noted, which impacted the overall effectiveness and acceptance of the robots.

A better approach of integrating existing social and healthcare as well as pharmacy systems with robot software solutions is needed. This study supports the importance of co-designing and evaluating social robot interventions in real-life scenarios. However, due to limited prior research, further development and testing of social robots for specific medication process interventions is recommended.

Keywords: social robots, medication counselling, medication safety, health care

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Introduction

A successful and safe medication process is a central part of clients' comprehensive care. It is emphasized that 18.3% of common safety incidents in the social and healthcare sector are related to medication errors [1] and that safety incidents can occur in any phase or in any unit involved in medication processes [2-5]. The medication process includes the following five steps: a) ordering/prescribing, b) transcribing and verifying, c) dispensing and delivering, d) medication administering, e) monitoring and reporting of medications [6-8]. The ordering/prescribing includes processes where healthcare professionals decide which medication a client should receive. Transcribing/verifying includes ensuring that the prescription or medication order is correctly documented in the client's record, and verifying the details. Dispensing/ delivering includes preparing and providing the prescribed medication to the client with correct medication, and ensuring it reaches the client. Medication administering includes giving the prescribed medication to the client. Monitoring/ reporting includes patient safety and treatment effectiveness by reporting responses to medication [6-8]. With a safe medication process both diseases and symptoms in this way might be cured or alleviated as well as the progression of further diseases might be prevented [1,9]. Prior research [10] indicates that new digital solutions, for example, social robots with integrated artificial intelligence might prevent some issues and error incidents that can occur in connection with a client's medication process.

A social robot can be defined as a robot designed to interact, perform services and operate in a natural, efficient and a socially acceptable way with humans in humanlike environments [11]. A unifying factor for social robots is to engage in an interpersonal manner with humans in both verbal and nonverbal interactions [11,12]. Social robots have been tested in different types of areas, such as education [13], and healthcare services [14-16]. Prior, social robots were developed for medication processes, such as administering as well as monitoring and reporting. For instance, social robots were developed to remind older persons of their medication schedules [17] and to monitor the medication and diet adherence of older persons [18]. Evaluations from these studies have been mainly positive related to user experiences, even if some of the older persons reported barriers related to their adoption of new technologies and that the learning effect could fade [18]. In a prior study [19], a social robot was also tested to manage and support the everyday medication of an older person. The study particularly addressed the development process of the robot prototype and no real test scenarios with clients were performed.

As a shortage of pharmacists and care professionals worldwide has occurred [20], an increased feeling of stress and high-volume workload have been reported among social and healthcare workers [21]. The lack of time or insufficient knowledge (e.g. language skills of clients) can constitute obstacles in medication processes [22-24]. The lack of time might also lead to an inappropriate storage of medications [25]. While these technologies can help alleviate some of the administrative and routine burdens, it is important to note that they are not intended to replace nurses or healthcare professionals. A comprehensive review would help identify current trends, gaps in knowledge, and best practices, providing a clearer understanding of how these technologies can be most effectively implemented. The aim of this study was to examine the use of social robot interventions in medication processes, and to identify outcomes associated with such interventions.

Material and methods

As research regarding social robot interventions in the social and healthcare sector is rapidly increasing [26], a scoping review was determined to be the most relevant study method for this study [27,28]. To ensure quality, this study follows professional research ethics guidelines [29], as well as the checklist, Enhancing the Quality and Transparency of Health Research [30,31]. The study has also been reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping reviews (PRISMA-ScR) guidelines for scoping reviews. Ethical approval is not required for a scoping review [cf. 32].

Identifying relevant studies

A systematic search was conducted in the electronic databases PubMed, EBSCOhost, CINAHL and MEDLINE due to their applicability to the study area. Additional studies were selected through manual searches, including free searches on Google Scholar, as well as snowball searches. In the snowball search process, the authors began with a few key articles and used their reference lists to identify more relevant studies. The authors examined reference lists and book chapters to find additional sources. Grey literature was included in the search process to ensure comprehensiveness, with reports, theses, conference proceedings, and government or organizational publications being considered. Due to the rapid development of using robots in the field, the included studies had to have been published between 2018-2024. Two literature searches were conducted as part of this scoping review. The main search was conducted in May 2023 on studies published between 2018-2023. To capture any new studies published after the main search, a second search was conducted in June 2024 on studies published between 2023-2024. Search terms were discussed in consultation with an experienced librarian (MIT Libraries). The search terms followed the Population Concept Context (PCC) principles [33]. The search terms and variations for each database can be found in appendix 1.

A study was considered eligible if it assessed the use of a social robot in medication processes with participation feedback. Studies including other robots than social robots with the above-mentioned social robot definition [11] were excluded (e.g., prosthetic robots, robotic medicine dispenser). Also excluded were studies focusing on software programs, mobile robots or telepresence robots, unless they were used as a part of a social robot such as iRobi [34]. The studies had to have full-text available and written in English or in the Nordic languages such as Swedish, Finnish, Danish, and Norwegian.

Study selection

The identification and screening process for the main and second literature search is presented with the PRISMA-ScR flowchart in Figure 1. The search results of studies for screening used a two-stage approach. One author (MA) screened the selected studies by title. After the first stage, three authors (MA, SR, LE) screened the selected studies, first by abstract and then by full text. The full text studies identified as eligible for inclusion in this study were reviewed by all four authors (MA, SR, LE, SH) to ensure credibility. Discrepancies between reviewers were reconciled through discussion when necessary.

A total of 2095 studies were retrieved across both searches. After removing duplicates, 1373 studies remained for screening. Of these, 1291 were excluded for lack of relevance, and 92 studies proceeded to screening by title and abstract. Following this, 72 studies were excluded, and 20 full-text studies were reviewed. A total of 7 full-text studies across both searches met the eligibility criteria for inclusion in this review.

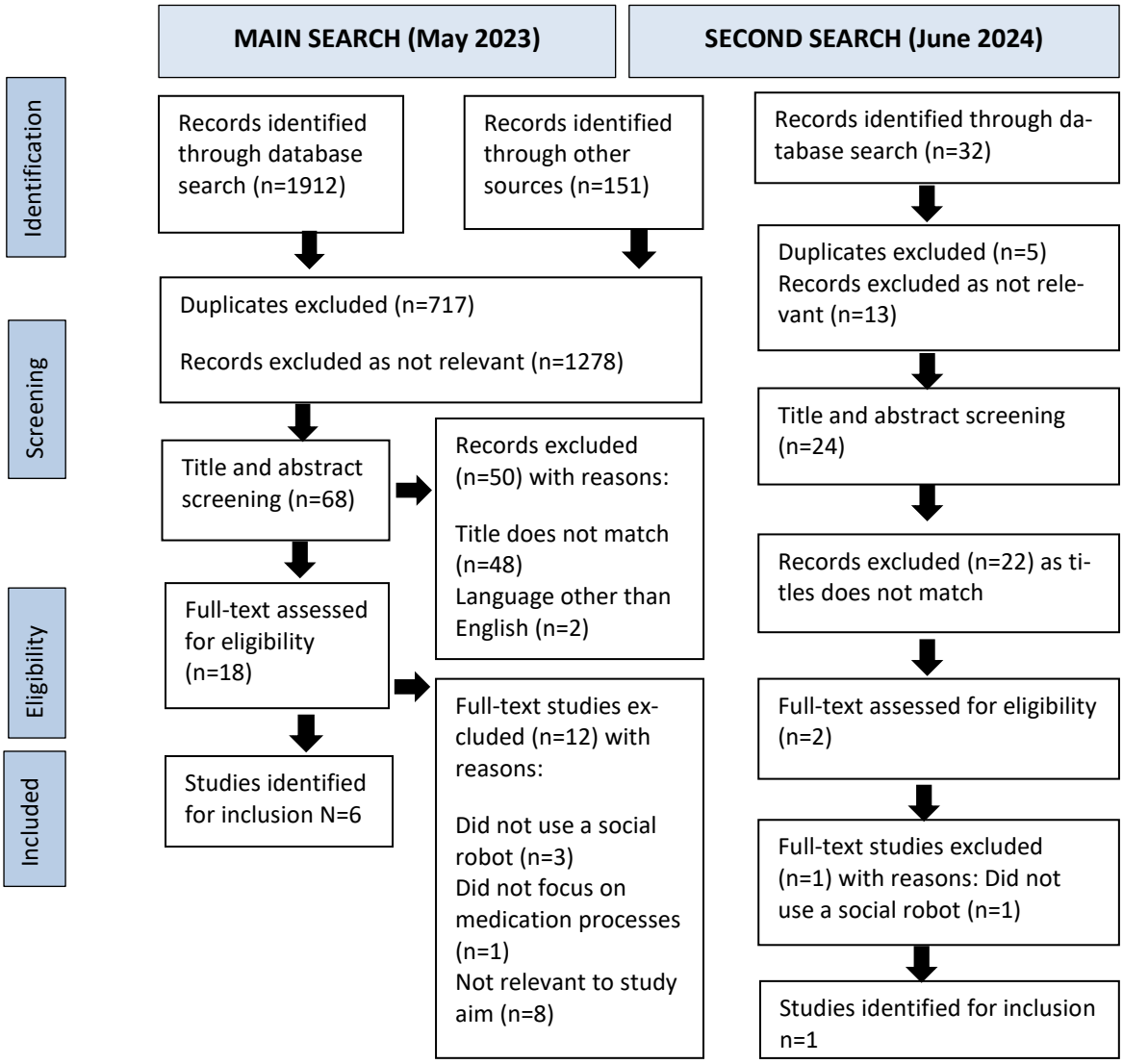

Figure 1. The screening and identification process of the main and the second literature search.

Extracting data

The following data were extracted from each selected study: interventions in medication processes, author(s), year of publication, country of origin, study population, sample size, methods adopted, study context, used robot, intervention type, duration of intervention (see Table 1).

The studies were also grouped in accordance with the five stages included in the medication process [cf. 6-8]. When determining the robot intervention related to the medication process, the five stages were created by the authors and are not outwardly referenced or defined by the studies from which they are identified.

Results

The social robots performed a wide variety of tasks, and all the seven studies included more than one robot intervention/function. Across the studies, 86 participants were included, but due to some reports being inconsistent, overall gender and age information are not available. Participants were

clients, relatives, students, or professionals in the social and healthcare sector. The following stages in medication processes [cf. 6-8], were distinguished in the social robot interventions; a) Dispensing and delivering, b) Medication administering, c) Monitoring and reporting.

Table 1. Social robot interventions.

Interventions in medication processes	Author(s) / year of publication / Country of origin	Population/ methods adopted/ study context	Used robot / intervention type/ duration of the intervention
Dispensing and delivering	[37] 2024, Finland	Eight community pharmacists Focus group interviews In a laboratory setting	Furhat The robot acted as pharmacist, offered medication counselling and answered questions regarding emergency contraceptive pills One test scenario
	[38] 2018, USA	31 students from a university Questionnaire, video In a laboratory setting	Nao and a virtual robot, which was a simulation of the Nao robot The robot provided cognitive and social support to participants sorting two medications on their own. One test scenario
	[40] 2020, Portugal	Two test persons aged between 50 and 60 years User recognition In a laboratory setting	Nao The robot identified the correct medication package, detected the right person to take the medication and ensured the medication was taken at the right time. Two test scenarios and one experiment
Medication administering	[34] 2018, Australia	52 clients with chronic obstructive pulmonary disease Questionnaire and interviews In participants' own home	iRobi The robot measured pulse oximetry, heart rate, forced expiration volume, symptoms, functional state, and mental state; reminded to take inhalers and medications; recorded clients' adherence and supported education. 4 months
	[35] 2020, Australia	4 hospital clinic clients aged 13-16 years Interviews, questionnaire At a hospital clinic	Nao The robot delivered a talk-based counselling approach related to diabetes management and promoted behavior change ideas needed for insulin use 8 weeks
	[36] 2022, New Zealand	Six older persons Interviews In participants own home	Bomy The robot used six games; Cooking, Dressing Up, Hide and Seek, Block Matching, Find It Quickly and Memory. Nine types of reminders were also available e.g., reminded to take medications and gave details on any other relevant medication information. Up to one week
Monitoring and reporting	[39] 2022, Greece	12 older persons with mild cognitive impairments User recognition In participants' own home	RAMCIP The robot navigated for the right person, reminded about medication, grasped medication packages, communicated about medication adherence, monitored medication activities, and released medication packages to its original storage. Seven days or more

Table 2 Category of the studies and characteristics of the social robots.

Type of robot	Characteristics	Dispensing and delivering	Medication administering	Monitoring and reporting
iRobi	45 cm tall with capabilities of moving on wheels, speaking and manifesting emotions. The robot can interact with its surroundings.		1	
RAMCIP	No information of size available. Capabilities of communicating. The robot can provide assistance.			1
Bomy	63 cm tall with capabilities of communicating and providing exercise cognitive training.		1	
NAO	58 cm tall with capabilities of walking, speaking, manifesting emotions and gesticulating. The robot can interact with its surroundings.	2	1	
Furhat	41 cm tall face with capabilities of customized facial animations and voices. The robot can interact with its surroundings.	1		

Dispensing and delivering

Three studies [37-39] examined a social robot for dispensing or delivering medications. Due to prior research [7-9], dispensing and delivering includes preparing and providing the prescribed medication to the client with correct medication, in the right dose and form, and ensuring that the prescribed medication reaches the client.

One study [37] found that pharmacists believe the social robot Furhat can effectively complement human pharmacists, particularly for certain customer groups and to address personnel shortages. However, they noted the robot's lack of body language as a disadvantage, limiting its ability to interpret nonverbal cues. Reactions to the robot's appearance varied; some felt nervous, while others found its human-like features increased trust. Pharmacists were concerned that using the robot for medication counselling in non-traditional settings, like grocery stores, could reduce trustworthiness and impact medication safety. They emphasized the need for a human pharmacist to handle technical or communication issues, ensuring safety, and insisted that customers should always have the option to consult a human pharmacist.

In another study [38], Nao demonstrated varying effectiveness in supporting human autonomy during medication sorting. The initial evaluation aimed to enhance the robot's practical applicability beyond virtual simulations, enabling it to assist when pills were misplaced or participants were slow in sorting. In the final evaluation, the robot provided cognitive and social support while organizing two different medications for the week, which were to be taken at different times of the day throughout the week. The students' experiences varied depending on whether they greeted the physical or virtual robot. Those who greeted the physical robot rated its supportive assistance and emotional support lower than those who did not greet it. In

contrast, greeting the virtual robot resulted in higher ratings.

The results from the last study [40], in which Nao was tasked with recognizing medication packages, were generally positive but showed room for improvement. The robot recognized 26 of 30 ben-u-ron packages and 17 of 20 other packages, resulting in a detection rate that was considered moderately high by the middle-aged test participants. In addition, the robot recognized 123 of 150 facial images, which was rated as only quite high as it should detect all facial images correctly. In the experiment, Nao recognized the right medication and the right person who should take the medication. In addition, Nao provided information about the medication to the correct person, which was rated as a successful outcome.

Medication administering

Three studies [34-36] used a social robot in administering medication. This stage in the medication process includes giving the prescribed medication to the client. This involves ensuring the correct drug, dose, route, and time of administration [7-9]. Almost all studies using a social robot for medication administration reported positive outcomes.

In a study where the social robot iRobi was used for clients with COPD, the intervention group showed improved adherence to medication and home rehabilitation [34]. Clients felt supported by the robot in medication management, companionship, and education with frequent use of the medication reminder function linked to increased adherence. However, there was no significant difference in hospital days between the intervention and control groups. Technical issues, such as problems with the pulse oximeter and network connection, were reported. While most clients had positive experiences, some were uncomfortable with having the robot in their homes, leading a few to return iRobi early. Reasons included finding the robot unnecessary for their medication management or feeling unnerved by its presence.

In another study [35], Nao's coaching and informing young clients with Type I Diabetes in diabetes management showed promising results regarding the use of a social robot to deliver motivational mental imagery-based interventions. Nao demonstrated effectiveness in helping the clients reduce their intake of high-energy foods and drinks. The intervention also explored Nao increased the clients' motivation and confidence during the period of use. The use of Nao did elicit discussions regarding personal goals, strategies, and personal incentive. Despite the lack of personalization, ratings of the robot's qualities, such as trust, helpfulness and likability increased over time. The sessions were rated as both supportive and interactive.

In the last study [36], the interventions provided by the robot Bomy assessed its effectiveness in reminding older adults about daily activities and cognitive games, with participants finding these reminders helpful. The health-related reminders were particularly valued for managing health needs. All older persons engaged in cognitive games and opted for medication reminders, such as pill-taking and daily blood pressure checks. However, they felt the robot's reminder function would be even more beneficial for others, especially those with complex health needs, lower cognitive functioning, or limited access to reminder technologies.

Monitoring and reporting

Only one study [39] used a social robot in monitoring or reporting medications. Monitoring and reporting includes patient safety and treatment effectiveness by reporting responses to medication, including side effects and complications [6-8].

The social robot RAMCIP monitored and reported medications, achieving 80% accuracy in assisting older adults with medication adherence scenarios. Out of 84 scenarios, 68 were performed correctly. A scenario was considered correct only if the robot returned to the monitoring state and confirmed whether the participant had taken their medication. However, errors in the robot's functions- such as issues with its actions, perception, and communication- led to uncertainty about medication intake, stemming from its actions, perception, and communication skills. Additionally, the robot sometimes failed to recognize when participants had taken their medication, resulting in unnecessary reminders [39].

Discussion

Overall, the outcomes from the studies indicate that these robots can effectively support medication adherence [34], assist with health management [35,39], and provide valuable companionship and reminders [36]. The results support prior research on social robots in the social and healthcare sector, showing that they are received positively [34,37,40]. However, even if a prior review [41] shows benefits of co-present robots (those physically present) over tele-present robots or virtual agents, the study results by Wilson et al. [38] remain unclear on whether a physical or virtual robot was better for dispensing medication. Future studies should explore how the presence (or absence) of a physical robot impacts user experience, trust, and the overall effectiveness of medication management. The social robot interventions were rated high in giving medication advice and counselling, and in providing medical education [34,37]. Some also experienced the robot as trustworthy during diabetes management [39]. The results indicate that using social robots to order and administer medications have good potential for further development and acceptance. In addition, the findings may be considered of interest for developers in their further development of robot technology in medication processes.

The results also demonstrate that factors such as higher ratings of trust might enable further implementation of social robots in medication processes [38]. Research should explore how different aspects of robot design, communication styles, and user interactions contribute to building trust over time. Repeated use of the robot showed increased medication adherence among the participants [34]. This is consistent with prior research [42], showing benefits with long-term robotic companionship. Consequently, even if studies with a longer-term perspective are lacking in the review, this indicates that repeated human-robot interaction in medication processes might facilitate habitual use and adherence over time.

However, technical issues, such as errors in recognizing medication intake, communication limitations [39], and user discomfort [34], were also noted, impacting the overall effectiveness and acceptance of the robots. While social robots showed promise in enhancing user engagement and support, challenges related to accuracy, reliability, and user comfort need to be addressed to fully optimize their use in healthcare settings.

In studies conducted in the participants' homes, social robots had difficulty perceiving the participants' movements during the medication process [40]. In addition, issues with internet connections, pulse oxygen device [34], and other technical problems were found [38]. These obstacles led to several phone calls from participants to healthcare professionals, resulting in significant time spent troubleshooting technical issues [34]. There were also negative expressions toward the social robots' lack of personalization [39]. Some participants also

felt unnerved by having the robot staying in their home [40]. Even if some of the robots used was perceived as more positive than other robots [34], poorly designed robot systems that contribute to technology-induced errors have shown to be strongly affected by the robots' user interface design [43].

Compromising the safety of medication processes can lead to serious side effects for clients [37,44]. The improvement of safety features as well as better aesthetics to increase usability similar to medication prescription systems are needed [45]. These findings indicate that further research should focus on how to counteract errors in the robots' user interface designs for improved medication processes. In addition, this study's results show that including relevant participants, such as pharmacist [37] in the development phase of robot technologies allows for a rapid prototype and evaluation of different designs. The findings support the development of robot technologies through several build-up phases, starting together with both relevant end-users and participants to design sustainable robot interventions for medication processes.

This study's result also found some robot prototypes were more time-consuming than original systems in pharmacies [45]. In addition, some emphasized the importance of always having a human pharmacist available to address any technical or communication issues with the robot, ensuring medication safety [37]. For the successful implementation of robot technologies, the lack of technical development and socio-institutional adaption must be addressed. Additionally, a socio-technical transition in the social and healthcare sector is required, as management and policy measures must be considered [46]. The study's findings suggest substantial improvements before implementing robots into pharmacies. For instance, the robot dispensing system needs to have details of the client, prescriber, and medication visible to decrease the risk of omission of medications, as well as to increase the robot's ease of use and to integrate its system with those of the existing pharmacy. These findings provide valuable next steps for future social robot research in medication processes and again highlight the importance of developing robot technologies together with relevant end-users.

Lessons learned and future directions

Although the geographic scope of the studies included in this review is limited to Finland [37], the USA [38], Portugal [40], Australia [35], New Zealand [36], and Greece [39], this concentration on these countries may offer valuable insights from regions with advanced healthcare systems and stronger research infrastructures [47]. These countries have demonstrated significant interest and investment in the development and integration of social robots in healthcare, which may provide a more in-depth understanding of their practical applications in medication processes.

These interventions are consistent with the WHO [48] Global Strategy on Digital Health 2020-2025 stating that digital healthcare technologies should be designed and implemented on a broad front and sustainable enough to be used for a longer time. Continuous dialogue between sectors and society, along with the involvement of relevant participants, might enable the further implementation of robots in the social and healthcare sector [46]. As the development of robots assisting humans' proceeds, a human-centric approach needs to be continued. Further research cannot simply evaluate humans' experiences of how well a robot can assist with a task but should also consider the effects the robot may have on the person being assisted [35]. The functions and factors associated with social robot interventions in medication processes begin to

paint a picture of an optimal structure for social robots to be used in medication processes. Therefore, a better approach is needed that integrates existing social and healthcare as well as medical/pharmacy systems with robot software solutions to reduce workload and to incorporate safety [45]. Further investigation into integrating robots at earlier stages of the medication process could enhance their role in improving medication safety, accuracy, and efficiency. Thus, the usability of sustainable and useful social robot interventions in medication processes can be achieved.

Conclusion

Overall, the studies indicate that social robots can effectively support medication adherence, assist with health management, and provide valuable companionship and reminders. Technical issues, such as errors in recognizing medication intake, communication limitations, and user discomfort were also noted, which impacted the overall effectiveness and acceptance of the robots. This study's findings suggest that substantial improvements are needed before implementing robots into pharmacies. This study supports previous literature emphasizing the importance of co-designing and evaluating social robot interventions in real-life scenarios for which they have been developed. Nonetheless, as prior research in this area is scant, additional interventions in which social robots are further developed and tested for specific medication process interventions is recommended.

Strengths and limitations

The authors chose to exclude the focus on study context in the search terms. As numerous terms related to social robots are used [49], the search terms related to social robots may have missed relevant literature, such as field of the autism spectrum in various domains [50]. The study primarily was to emphasise the human and social aspects rather than the purely technical dimensions. As a result, authors concentrated on sources and databases that align more closely with healthcare, caregiving, and related social sciences to ensure a comprehensive exploration of the care-related context.

A quality rating of the seven studies in accordance, as outlined in Arksey and O'Malley's scoping review framework [27], was not included. Future research should consider the varied taxonomy of social robots and their discipline origins, as some studies do not focus on medication processes per se, but rather on rehabilitation or therapy such as emotional or motor outcomes. The geographic scope of the included studies is limited to a few countries, which may reduce the generalizability of the findings due to differences in culture, economy, and healthcare system.

Declarations

Code availability Not applicable.

Declaration of Interest statement

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References

[1] World Health Organization. Patient safety: Making health care safer [Internet]. Geneva: World Health Organization; 2017 [cited 11th April 2023]. Available from: https://apps.who.int/iris/handle/10665/255507

[2] Björkstén KS, Bergqvist M, Andersén-Karlsson E, Benson L, Ulfvarson J. Medication errors as malpractice-a qualitative content analysis of 585 medication errors by nurses in Sweden. BMC Health Serv Res. 2016 Aug 24;16(1):431. https://doi.org/10.1186/s12913-016-1695-9

[3] Henriksen JN, Nielsen LP, Hellebek A, Poulsen BK. Medication errors involving anticoagulants: Data from the Danish patient safety database. Pharmacol Res Perspect. 2017 Apr 3;5(3):e00307. https://doi.org/10.1002/prp2.307

[4] Mulac A, Taxis K, Hagesaether E, Gerd Granas A. Severe and fatal medication errors in hospitals: findings from the Norwegian Incident Reporting System. Eur J Hosp Pharm. 2021 Nov;28(Suppl 2):e56-e61. https://doi.org/10.1136/ejhpharm-2020-002298

[5] Ministry of Social Affairs and Health. The Client and Patient safety Strategy and Implementation Plan 2022-2026. Publications of the Ministry of Social Affairs and Health 2022: 12. Helsinki: Ministry of Social Affairs and Health; 2022 [cited 11th April 2023]. https://urn.fi/URN:ISBN:978-952-00-9712-7

[6] Aspden P, Wolcott JA, Bootman JL, Cronewett LR (eds). Preventing Medication Errors [Internet]. Institute of Medicine. Washington DC; National Academy Press; 2007 [cited 11th April 2023]. Available from: https://nap.nationalacademies.org/read/11623/chapter/1

[7] Hughes RG, Blegen MA. Medication Administration Safety. In: Hughes RG (ed). Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Rockville (MD): Agency for Healthcare Research and Quality (US); 2008. p. 37.

[8] Vogenberg FR, Benjamin D. The medication-use process and the importance of mastering fundamentals. P T. 2011 Oct;36(10):651-2. https://doi.org/10.1097/01.NPR.0000405153.55407.72

[9] World Health Organization. Medication Without Harm [Internet]. Geneva: World Health Organization; 2017 March [cited 12th April 2023]. Available from: https://www.who.int/initiatives/medication-without-harm

[10] Tanioka T, Smith MC, Zhao Y. Framing the development of humanoid healthcare robots in caring science. International Journal for Human Caring. 2019;23(2):112-120. https://doi.org/10.20467/1091-5710.23.2.112

[11] Breazel C, Dautenhahn K, Kanda T. Social robotics. In: Siciliano B, Khatib O (eds). Springer Handbook of Robotics. 2nd edition. Springer International Publishing; 2016. p. 1935-1972. https://doi.org/10.1007/978-3-319-32552-1_72

[12] Mahdi H, Akgun SA, Saleh S, Dautenhahn K. A survey on the design and evolution of social robots - Past, present and future. Robotics and Autonomous Systems. 2022;156. https://doi.org/10.1016/j.robot.2022.104193

[13] Belpaeme T, Kennedy J, Ramachandran A, Scassellati B, Tanaka F. Social robots for education: A review. Science Robotics. 2018;3(21). https://doi.org/10.1126/scirobotics.aat5954

[14] Anghel I, Cioara T, Moldovan D, Antal M, Pop CD, Salomie I, Pop CB, Chifu VR. Smart

Environments and Social Robots for Age-Friendly Integrated Care Services. Int J Environ Res Public Health. 2020 May 27;17(11):3801. https://doi.org/10.3390/ijerph17113801

[15] Nyholm L, Santamäki-Fischer R, Fagerström L. Users' ambivalent sense of security with humanoid robots in healthcare. Inform Health Soc Care. 2021 Jun 2;46(2):218-226. https://doi.org/10.1080/17538157.2021.1883027

[16] Hägglund S, Fagerström L, Nyholm L. Promoting human and planetary health simultaneously by addressing sustainability on an holistic, multidimensional level in the design and use of SARs in healthcare. International Journal of Caring Sciences. 2022;15(1): 650-654.

[17] Wu YH, Wrobel J, Cornuet M, Kerhervé H, Damnée S, Rigaud AS. Acceptance of an assistive robot in older adults: a mixed-method study of human-robot interaction over a 1-month period in the Living Lab setting. Clin Interv Aging. 2014 May 8;9:801-11. https://doi.org/10.2147/CIA.S56435

[18] Ishiguro K, Majima Y, Sakata N. Deployment of ARCS Model and Utilization of Communication Robot in Patient Education. In: Proceedings of the 9th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2016, 21-23 February 2016, Rome, Italy). HEALTHINF, vol 5. SciTePress; 2016. p. 371-376. https://doi.org/10.5220/0005774603710376

[19] Schweitzer M, Hoerbst A. Robotic Assistance in Medication Management: Development and Evaluation of a Prototype. Stud Health Technol Inform. 2016;225:422-6. https://doi.org/10.3233/978-1-61499-658-3-422

[20] Yuniar Y, Herman MJ. Overcoming Shortage of Pharmacists to Provide Pharmaceutical Services in Public Health Centers in Indonesia. Kesmas National Public Health Journal. 2013;8(1):3-8. https://doi.org/10.21109/kesmas.v8i1.334

[21] Härkänen M. Medication-related Adverse Outcomes and Contributing Factors among Hospital Patients - An Analysis Using Hospital's Incident Reports, the Global Trigger Tool Method, and Observations with Record Reviews. Publications of the University of Eastern Finland, Dissertations in Health Sciences 260. University of Eastern Finland; 2014. http://urn.fi/URN:ISBN:978-952-61-1636-5

[22] Aaltonen SE, Laine NP, Volmer D, Gharat MS, Muceniece R, Vitola A, Foulon V, Desplenter FA, Airaksinen MS, Chen TF, Bell JS. Barriers to medication counselling for people with mental health disorders: a six country study. Pharm Pract (Granada). 2010 Apr;8(2):122-31. https://doi.org/10.4321/S1886-36552010000200007

[23] Wabe NT, Raju NJ, Angamo MT. Knowledge, attitude and practice of patient medication counseling among drug dispensers in North West Ethiopia. J Appl Pharm Sci. 2011;1(7):85–90.

[24] Urbanek K. Medication Errors in intravenous drug preparation and administration: a brief review. J Nurs Care. 2017;4(5). Htpps://doi.org/10.4172/2167-1168.1000285

[25] Valvira. Vanhusten hoivapalvelujen kriisi ei saa toistua [Internet]. Valvira; 2019 [cited 1st Oct 2024]. Available from: https://valvira.fi/-/vanhusten-hoivapalvelujen-kriisi-ei-saa-toistua

[26] Buvailo A. The Why, How and When of AI in the Pharmaceutical Industry [Internet]. Forbes Magazine; 2018 April [cited 11th April 2023]. Available from: https://www.forbes.com/sites/forbestechcouncil/2018/04/24/the-why-how-and-when-of-ai-in-the-pharmaceutical-industry/#25dcad846d07

[27] Arksey H, O'Malley L. Scoping studies: towards a methodological framework. International Journal of Social Research Methodology. 2005;8(1):19–32. https://doi.org/10.1080/1364557032000119616

[28] Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci. 2010 Sep 20;5:69. https://doi.org/10.1186/1748-5908-5-69

[29] Peters M, Godfrey C, Mcinerney P, Soares C, Khalil H, Parker D. Methodology for JBI scoping reviews. In: Aromataris E (ed). The Joanna Briggs Institute reviewers´ manual 2015. South Australia: Joanna Briggs Institute; 2015. p. 3-24.

[30] Altman DG, Simera I, Hoey J, Moher D, Schulz K. EQUATOR: reporting guidelines for health research. Lancet. 2008 Apr 5;371(9619):1149-50. https://doi.org/10.1016/S0140-6736(08)60505-X

[31] Moher D, Simera I, Schulz KF, Hoey J, Altman DG. Helping editors, peer reviewers and authors improve the clarity, completeness and transparency of reporting health research. BMC Med. 2008 Jun 16;6:13. https://doi.org/10.1186/1741-7015-6-13

[32] Finnish National Board on Research Integrity. The Finnish Code of Conduct for Research Integrity and Procedures for Handling Alleged Violations of Research Integrity in Finland [Internet]. Helsinki: TENK; 2023 [cited 1st Oct 2024]. Available from: https://tenk.fi/sites/default/files/2023-11/RI_Guidelines_2023.pdf

[33] Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z (eds). JBI Manual for Evidence Synthesis [Internet]. JBI; 2024. https://doi.org/10.46658/JBIMES-24-01

[34] Broadbent E, Garrett J, Jepsen N, Li Ogilvie V, Ahn HS, Robinson H, Peri K, Kerse N, Rouse P, Pillai A, MacDonald B. Using Robots at Home to Support Patients With Chronic Obstructive Pulmonary Disease: Pilot Randomized Controlled Trial. J Med Internet Res. 2018 Feb 13;20(2):e45. https://doi.org/10.2196/jmir.8640

[35] Robinson NL, Connolly J, Hides L, Kavanagh DJ. A social robot to deliver an 8-week intervention for diabetes management: Initial test of feasibility in a hospital clinic. In: Wagner AR et al. Social Robotics. ICSR 2020. Lecture Notes in Computer Science 2020 vol 12483. Springer, Cham; 2020. https://doi.org/10.1007/978-3-030-62056-1_52

[36] Gasteiger N, Ahn HS, Fok C, Lim J, Lee C, MacDonald BA, Kim GH, Broadbent E. Older adults' experiences and perceptions of living with Bomy, an assistive dailycare robot: a qualitative study. Assist Technol. 2022 Jul 4;34(4):487-497. https://doi.org/10.1080/10400435.2021.1877210

[37] Rosenberg S, Andtfolk M, Hägglund S, Wingren M, Nyholm L. Social robots counselling in community pharmacies - Helping or harming? A qualitative study of pharmacists' views. Explor Res Clin Soc Pharm. 2024 Feb 24;13:100425. https://doi.org/10.1016/j.rcsop.2024.100425

[38] Wilson JR, Lee NY, Saechao A, Tickle-Degnen L, Scheutz M. Supporting human autonomy in a robot-assisted medication sorting task. International Journal of Social Robotics. 2018;10:621-641. https://doi.org/10.1007/s12369-017-0456-1

[39] Kostavelis I, Kargakos A, Skartados E, Peleka, G, Giakoumis D, Santapoulos I, Agriomallos I, Doulgeri Z, Endo S, Stüber H, Janjoš F, Hirche S, Tzovaras D. Robotic Assistance in Medication Intake: A Complete Pipeline. Applied Sciences. 2022;12(3):1379. https://doi.org/10.3390/app12031379

[40] Crisótomo L, Fonseca Ferreira NM, Filipe V. Robotics services at home support. International

Journal of Advanced Robotics Systems. 2020;17(4)1-11. https://doi.org/10.1177/1729881420925018

[41] Li J. The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents. Int J Human-Comput Stud. 2015;77:23–37. https://doi.org/10.1016/j.ijhcs.2015.01.001

[42] Abdollahi H, Mollahosseini A, Lane JT, Mahoor HM. A pilot study on using an intelligent life-like robot as a companion for elderly individuals with dementia and depression. 2017 IEEE-RAS International Conference on Humanoid Robots. Birmingham, UK: IEEE; 2017. https://doi.org/10.1109/HUMANOIDS.2017.8246925

[43] Kushniruk AW, Borycki EM (eds). Human, Social, and Organizational Aspects of Health Information Systems. Hershey, United States: IGI Global; 2008. https://doi.org/10.4018/978-1-59904-792-8

[44] Assiri GA, Alkhenizan AH, Al-Khani SA, Grant LM, Sheikh A. Investigating the epidemiology of medication errors in adults in community care settings. A retrospective cohort study in central Saudi Arabia. Saudi Med J. 2019 Feb;40(2):158-167. https://doi.org/10.15537/smj.2019.2.23933

[45] Martini N, Broadbent E, Koo J, Lam L, Verches D, Zeng S, Montgomery-Walsh R, Sutherland C. Investigating the Usability, Efficacy and Accuracy of a Medication Entering Software System for a Healthcare Robot. Front Robot AI. 2022 Jan 25;9:814268. https://doi.org/10.3389/frobt.2022.814268

[46] Pekkarinen S, Hennala L, Tuisku O, Gustaffson C, Johansson-Pajala RM, Thommes K, Hoppe JA, Melkas H. Embedding care robots into society and practice: Socio-technical considerations. Futures. 2020;122:102593. https://doi.org/10.1016/j.futures.2020.102593

[47] World Health Organization. Everybody's business. Strengthening health systems to improve health outcomes: WHO's framework for action [Internet]. Geneva: World Health Organization; 2007 [cited 11th April 2023]. Available from: https://iris.who.int/bitstream/handle/10665/43918/9789241596077_eng.pdf

[48] World Health Organization. Aging and health [Internet]. WHO; 2021 Oct [cited 12th April 2023]. Available from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

[49] González-González CS, Violant-Holz V, Gil-Iranzo RM. Social robots in hospitals: A systematic review. Applied Sciences. 2020;11(13):5976. https://doi.org/10.3390/app11135976

[50] Kouroupa A, Laws KR, Irvine K, Mengoni SE, Baird A, Sharma S. The use of social robots with children and young people on the autism spectrum: A systematic review and meta-analysis. PLoS One. 2022 Jun 22;17(6):e0269800. https://doi.org/10.1371/journal.pone.0269800

Appendix 1.

The search terms followed the Population Concept Context (PCC) principals (Salmond & Benett, 2021), including:

Population:	Concept:	Context:
Student* or undergraduate or caregiver or carer or nurs* or staff'or employee* or workers or personnel or client* or patient* or customer or young* or adolescent* or aged or senior or elder* or older* or relative*	robot* or robotic* or social robot* or social assistive robot* or assistive robot* companion robot* or android* or humanoid*	medication* or medicine* or medicate* or medical* or medication intervention* or medication process* or medical procedure* medical treatment* or drug* or pharmaceutic* or medicament* or medical cure* or medication therapy*

Search terms used for PubMed, EBSCOhost, MEDLINE and Google Scholar were determined through the Medical Subject Headers (MeSH terms) and for CINAHL, the Subject Headings for CINAHL were used. All search terms were also included by Boolean operators such as "OR", "AND" as well as the asterisk (*) symbol to allow search terms to be treated as prefixes.