

# SOCIALLY ASSISTIVE ROBOTS: TOWARD AN ENHANCED INDEPENDENCE OF OLDER ADULTS

Sanja ŽIVKOVIĆ

University of Zagreb, Faculty of Economics and Business, J. F. Kennedy sq. 6, 10000 Zagreb,  
Croatia  
szivkovic@net.efzg.hr

Lucija IVANČIĆ

University of Zagreb, Faculty of Economics and Business, J. F. Kennedy sq. 6, 10000 Zagreb,  
Croatia  
ljuros@net.efzg.hr

Vesna BOSILJ VUKŠIĆ

University of Zagreb, Faculty of Economics and Business, J. F. Kennedy sq. 6, 10000 Zagreb,  
Croatia  
vbosilj@net.efzg.hr

## Abstract

*The world population is aging. At the same time, the ratio of working-age people to older adults is becoming increasingly unfavorable, and shortages in the health and social care workforce are already predicted. These trends call for new approaches to enhance the independence and well-being of older adults. Socially assistive robot (SAR) technology may provide an effective solution to the aging society problem. We present the results of a systematic literature review to provide answers on the roles and research topics related to SARs for older adults. Bibliometric and content analysis methods were used to analyze and synthesize qualitative data. The research results advance the understanding of the potential benefits and challenges of using SARs to enhance the independence of older adults living both at home and in long-term care facilities. We aim this understanding to be particularly valuable to policymakers, the leadership of health and social care institutions, non-government organizations representatives, and other stakeholders involved in designing and producing technological solutions for the aging population. Future research could be directed at examining country-specific ethical, legal, and technical factors related to the potential use of SARs for older adults.*

**Keywords:** socially assistive robots, older adults, elderly care, topic mapping, systematic literature review

**JEL classification:** J14, J18, O33

## Introduction

The aging population and the COVID-19 pandemic call for novel technological solutions to enhance the independence and well-being of older adults. By 2050, the percentage of the world's population older than 65 is expected to rise from 9.3% in 2020 to 16.0% (United Nations, 2020). At the same time, it is predicted that there will be a shortage of health and social care workers worldwide (World Economic Forum, 2021). These trends will have a major impact on elderly care in the European Union where the demographic old-age dependency ratio is projected to increase from 34% in 2019 to 59% in 2070 (European Commission, 2020). In

addition, the COVID-19 pandemic has shown that the well-being of older adults aging at home could be significantly impaired due to loneliness and isolation (Getson & Nejat, 2021). Socially assistive robot (SAR) technology could take on a special role in health and social care to meet the increasing demand for caregivers and improve the independence of older adults living both at home and in long-term care facilities.

Socially assistive robots can be defined as the intersection of assistive robotics and socially interactive robotics, whose main task is to interact with human individuals while performing assistive tasks (Feil-Seifer & Mataric, 2005; Vandemeulebroucke et al., 2021). Appropriate use of SARs in elderly care can have positive effects at the individual, institutional, and societal levels. In addition to improving the independence and well-being of older adults as end users, the use of assistive technologies also provides benefits to those who take care of them, such as family members, healthcare professionals, and the broader society (Khosravi & Ghapanchi, 2016). Furthermore, assistive robotics offers new opportunities for long-term care facilities in terms of reducing the workload of caregivers and solutions to the nursing shortage (Bonaccorsi et al., 2016; Tan et al., 2021). Socioeconomic benefits of the use of assistive technology are realized by reducing direct health and welfare costs, enabling a more productive labor force, and stimulating economic growth (World Health Organization, 2018, p. 3). Effective public policies and programs will be required to use the potential of new technologies in elderly care.

In order to consider SARs as an innovative solution to the care needs of the aging population, it is important to identify and disseminate research-based information about this form of technology (Papadopoulos et al., 2020). The perceived capabilities, usefulness, and potential roles of SARs can increase positive attitudes and influence intentions to adopt this technology in practice (Papadopoulos et al., 2018; Rantanen et al., 2018). Additionally, insights into the research topics on SARs can reveal the challenges connected to the implementation of this type of technology. Therefore, in our study, we attempt to answer two research questions, as follows. What are the roles of SARs for older adults? What are the topics in research on SARs for older adults? The main goal of this study is to advance policymakers' and other stakeholders' understanding of the potential benefits and challenges of using SAR technology to enhance the independence of older adults. The topic of this study is increasingly important from the socio-economic aspect. It gives guidelines to entrepreneurs in terms of designing and launching new products and services, and it also contributes to raising awareness in society of the potential positive effects of assistive technologies in addressing the challenges of the aging population.

## **Methods**

A systematic literature review was chosen as the research approach for this study. Compared to other methods of literature analysis, a systematic review is based on explicit criteria that ensure the reliability, completeness, and quality of findings (Okoli, 2015; Satalkina & Steiner, 2020; Tranfield et al., 2003). The study consisted of three steps: (1) definition of the systematic literature review protocol; (2) qualitative analysis and synthesis of the selected review articles using the content analysis method; and (3) bibliometric analysis using the keyword co-occurrence network. Content analysis is used to interpret the meaning of the content of text data (Hsieh & Shannon, 2005). Bibliometric analysis, on the other hand, allows researchers to gain an overview, identify knowledge gaps, and derive ideas for future research (Donthu et al., 2021). Therefore, the answers on the roles of SARs were based on the qualitative results of the detailed content analysis, while the bibliometric analysis guided the answers on the topics in research on SARs.

A systematic literature review research protocol was established for the first step of this research (Table 1). The search was conducted on December 24, 2021. The terms "social assistive robot" and "older adults" included in the title, abstract, and/or keywords were searched. The initial search resulted in 150 articles.

*Table 1: Systematic literature review research protocol*

Digital database	Web of Science Core Collection.
Search strategy	Searched terms "social assistive robot" and "older adults" contained in title, abstract and/or keywords; publications in the period 2012-2021.
Types of study	All study types.
Inclusion criteria (bibliometric analysis)	All research fields; journal articles, conference papers and review articles only; English language only.
Inclusion criteria (content analysis)	Review articles with full access.
Data synthesis strategy	Deductive coding approach, descriptive analysis, and visual presentation.

*Source: Authors' work*

The second and third research steps included the analysis of the articles. The bibliometric analysis was performed for all the articles found, while the content analysis was based on the review articles from the first research step. As a final result of the selection process, 32 articles were selected for content analysis and 150 for bibliometric analysis. The content analysis was performed using MS Excel, while the bibliometric analysis was performed using VOSviewer 1.6.13 software.

## **Results and discussion**

### ***Roles of socially assistive robots for older adults***

In this section, the summarized results of the content analysis are presented related to the roles of SARs for older adults. All 32 selected review articles are cited in this section. The content analysis started with setting the codes based on the recent findings of Getson and Nejat (2021) on the functions of SARs deployed during the COVID-19 pandemic with older adults. After iterative reviews, refining codes, and grouping findings, three main roles of SARs for older adults were identified: health monitoring; activity facilitation; and well-being enhancement.

*Health monitoring.* SARs are performing health monitoring roles by using telemonitoring, personal emergency response systems, wandering management systems, as well as other artificial intelligence solutions (Franke et al., 2021; Piau et al., 2014; Qiu et al., 2021). Health monitoring functions are mainly related to detecting a fall (Martinez-Martin et al., 2020), checking vital signs such as heart rate, heart rate variability, respiratory rate, respiratory and heart rate waveforms (Getson & Nejat, 2021; Moyle et al., 2017; Papadopoulos et al., 2018), and evaluating the sleep and daily physical exercise of older adults at their homes (Getson &

Nejat, 2021; Martinez-Martin et al., 2020). Certain types of SARs can serve as an extension of a care process when they are monitoring older adults and notifying health professionals, external caregivers, or relatives in case of emergencies (Getson & Nejat, 2021; Martinez-Martin et al., 2020; Vandemeulebroucke et al., 2018). During the COVID-19 pandemic, SARs also have a role in protecting older adults' health through implementing monitoring measures related to their visitors, such as measuring temperature upon entering facilities, checking for masks, and maintaining required physical distances (Getson & Nejat, 2021).

*Activity facilitation.* Tasks performed by SARs that are facilitating daily activities of older adults can be divided into household tasks, personal care tasks, and information and communication tasks. SARs are performing household tasks by autonomously navigating around the older adults' homes, going anywhere they request, bringing a specific object, being able to pick up objects from the ground and moving them to safe storage, checking the cooker has been turned off or the lights have been turned on when walking at night (Getson & Nejat, 2021; Martinez-Martin et al., 2020; Vandemeulebroucke et al., 2018; Vandemeulebroucke et al., 2021). In addition, they can also support older adults in cleaning (Franke et al., 2021; Vandemeulebroucke et al., 2021) and shopping (Vandemeulebroucke et al., 2021). Personal care tasks are mostly related to eating, bathing, dressing (Mois & Beer, 2020; Papadopoulos et al., 2018; Vandemeulebroucke et al., 2021; Zafrani & Nimrod, 2019), helping an older adult stand up from a sitting position (Papadopoulos et al., 2018), and providing indoor and outdoor walking support (Mansouri et al., 2017; Vandemeulebroucke et al., 2021). With regard to information and communication tasks, one of the most recognized roles of SARs is reminding older adults of taking medications, appointments, upcoming events, or where certain objects were placed (Gasteiger et al., 2021; Getson & Nejat, 2021; Ghafurian et al., 2021; Martinez-Martin et al., 2020; Vandemeulebroucke et al., 2018). They can also provide information about a healthy diet and weather forecast (Getson & Nejat, 2021; Ghafurian et al., 2021; Vandemeulebroucke et al., 2021), and assist older adults in web browsing and making calls (Vandemeulebroucke et al., 2021). Furthermore, SARs have a growing role in facilitating the social interaction of older adults with others, including family members, other residents at long-term care facilities, caregivers, or therapists (Abou Allaban et al., 2020; Campos Antunes et al., 2019; Ghafurian et al., 2021; Mois & Beer, 2020; Mois & Fortuna, 2020). By enabling video communication, telepresence robots are offering users an augmented communication channel that can be used to provide social connectedness, care, and medical consultations (Gongora Alonso et al., 2019; Hirt et al., 2021; Moyle et al., 2017; Qiu et al., 2021; Zafrani & Nimrod, 2019).

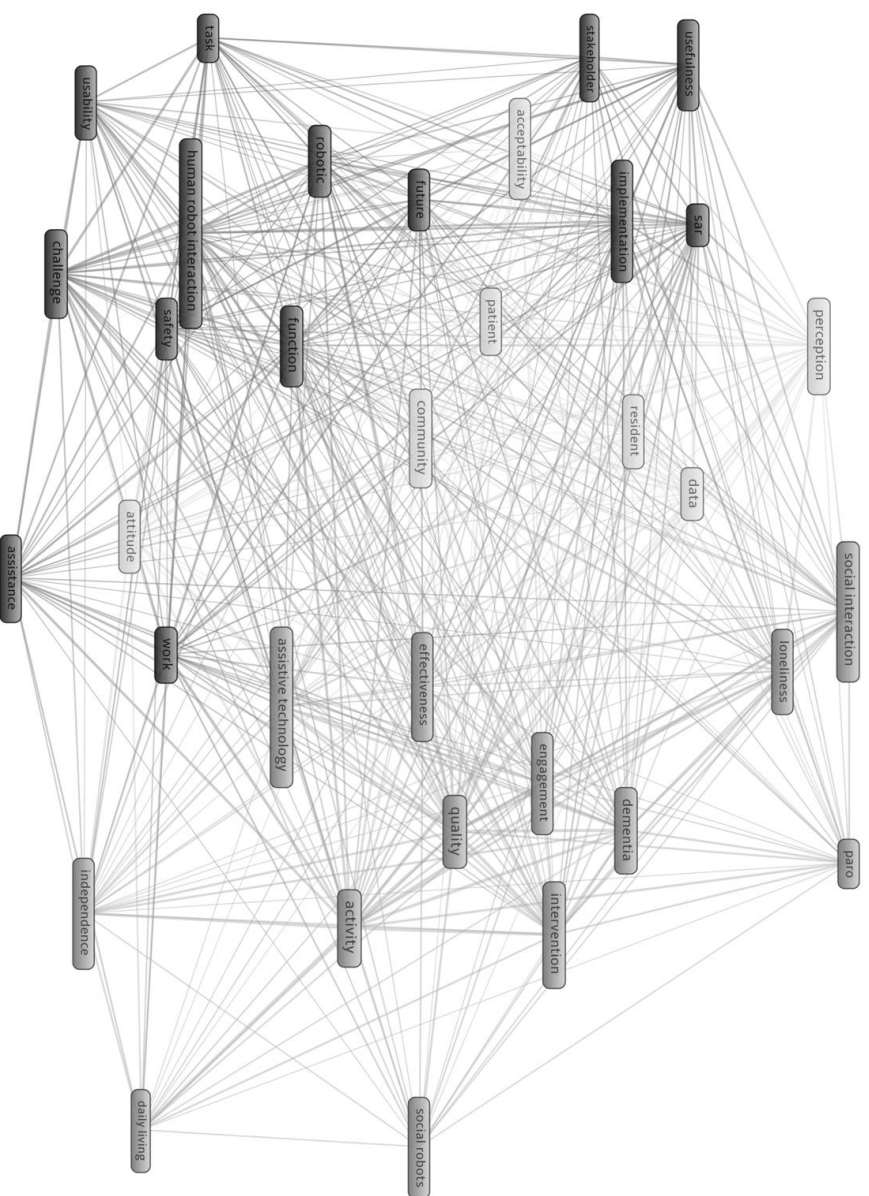
*Well-being enhancement.* SARs can have a role in providing assistance, therapy, and companionship aimed at improving older adults' physical, mental, and emotional well-being. With regard to promoting physical exercise, SARs can apply techniques based on the learning by imitation approach, evaluating the older adults' movements, recommending workouts, and providing them with feedback to improve their performance (Getson & Nejat, 2021; Martinez-Martin et al., 2020; Vandemeulebroucke et al., 2018). They are also used as an innovative tool for supporting physical rehabilitation and therapy, thereby helping to address care gaps due to increased patient survival after certain diseases (Abdi et al., 2018; Gerling et al., 2016; Langer et al., 2019). Additionally, SARs have a role in improving the mental health of older adults, especially those with dementia (Lu et al., 2021; Pu et al., 2019). They are used for cognitive assessments based on tests of work memory, arithmetic skills, reasoning, recall, and awareness (Mancioppi et al., 2019), as well as for cognitive stimulation through quizzes and specific music-based cognitive games (Gongora Alonso et al., 2019; Mancioppi et al., 2019; Martinez-Martin et al., 2020; Moyle et al., 2017). To improve aspects of cognition and mitigate cognitive

deficits, SARs can provide support in cognitive training and rehabilitation (Abdi et al., 2018; Getson & Nejat, 2021; Papadopoulos et al., 2020; Yuan et al., 2021). Such assistance approaches can improve individual social communication skills, which may include joint attention skills, imitation skills, and turn-taking skills (Yuan et al., 2021). Furthermore, SARs can enhance the emotional well-being of older adults by mediating patient-therapist relations and supporting therapy sessions, as well as by providing therapy more directly, such as pet and music therapy (Ghafurian et al., 2021). They can be used as an affective therapy tool aimed at improving the general mood of older adults, or their ability to overcome episodes of mood disturbance, such as anxiety and agitation (Abdi et al., 2018; Getson & Nejat, 2021; Papadopoulos et al., 2018; Papadopoulos et al., 2020). Pet robot interventions based on animal-assisted therapy are increasingly applied to reduce depression and loneliness levels (Budak et al., 2021; Hirt et al., 2021; Koh et al., 2021; Lu et al., 2021). Companion robots are designed to perform interactions with older adults in multiple forms, including visual, verbal, and emotive expressions (Abou Allaban et al., 2020). SARs with these functions are providing companionship to alleviate the loneliness or isolation of older adults through different forms of entertainment, such as telling stories, presenting the news, playing the radio or music on-demand, dancing, and singing (Gasteiger et al., 2021; Ienca et al., 2018; Kang et al., 2020; Kruse et al., 2020; Vandemeulebroucke et al., 2021).

### ***Mapping of topics in research on socially assistive robots for older adults***

In this section, the results of the bibliometric analysis are presented related to the topics in research on SARs for older adults. To facilitate the mapping of research topics, an analysis of the term co-occurrence network was performed based on the abstracts and titles of the articles. First, research terms were extracted from the articles. Initially, the software identified 55 terms as relevant for analysis. Nevertheless, some of the terms had to be excluded manually. These were, for example, general terms such as "total", "number", or "year", and methodology-related terms, such as "review", or "pubmed", and others. After removing the irrelevant terms, 34 terms remained for analysis. Based on these terms, a term co-occurrence network was created. Three clusters of terms were identified, shown in grayscale in Figure 1.

Figure 1. Term co-occurrence network visualization



Source: Authors' work

The first cluster is placed in the center of the map and is marked light grey. "Acceptability"; "attitude"; "community"; "data"; "patient"; "perception", and; "resident" are seven terms included in this cluster. The issues raised in this cluster relate to *Social awareness and perception of older adults* as relevant and (equally) important parts of the community. Although older adults are becoming a larger percentage of the population in many regions of the world due to demographic trends, the attitudes toward this population are not evolving proportionately. Moreover, they often carry negative connotations. Older adults are perceived as a cost and a burden to the community and the care system. Accordingly, they tend to be viewed as patients rather than residents. The social inclusion of older adults in the future may depend on the extent to which SAR technology is accepted in this population, which is the focus of interest in the other two clusters.

The second cluster is marked in black and placed on the left side of the picture. It includes fourteen terms. They are, respectively, "assistance"; "challenge"; "function"; "future"; "human robot interaction"; "implementation"; "robotic"; "safety"; "sar"; "stakeholder"; "task"; "usability"; "usefulness", and; "work". The future position of older adults in their communities and society depends on their prolonged optimal functioning. This functioning of older adults is concerning several important operability features: (i) assistance; (ii) safety, and; (iii) usability. The quality of human-robot interaction is key to the acceptance of SARs by a larger number of seniors. Accordingly, there are implementation challenges both in designing the SAR technology, as well as in improving the perceived usefulness of this technology by older adults. Therefore, the collaborative research efforts in this cluster can be characterized as *Technological and other implementation aspects as capabilities for SAR adoption and economic value*. The research also highlights the important role that other stakeholders play in facilitating the adoption process, such as caregivers and clinicians.

The third cluster is highlighted in dark grey and placed on the right side of the picture. It contains thirteen terms. The terms in this cluster include the following: "activity"; "assistive technology"; "daily living"; "dementia"; "effectiveness"; "engagement"; "independence"; "intervention"; "loneliness"; "paro"; "quality"; "social interaction", and; "social robots". Thus, the leitmotif of this cluster can be described as *Overcoming social and psychological barriers in aging through technology*. The daily living of older people can be challenging. They often suffer from dementia, which significantly limits their independence. Research has shown that independence can be regained to some degree when older adults use assistive technology. The SAR which is most frequently mentioned in the research is the PARO Therapeutic Robot. SARs also encourage activity and engagement among their users. This social interaction, in turn, reduces the risk of progression of various diseases such as dementia, as the elderly are particularly affected by loneliness. Apart from loneliness, older people may also live alone or find themselves alone in various situations. When help is needed in such a situation, their lives may depend on quick intervention. Assistive technologies play an important role in ensuring that help arrives in a timely manner. Therefore, the quality of daily life of elderly people can be greatly improved with the help of socially assistive robots.

## Conclusion

In summary, this study provides an overview of the roles and research topics related to SARs for older adults. The identified main roles of SARs for older adults are: health monitoring; activity facilitation; and well-being enhancement. Research topics mapped into clusters are associated with: social awareness and perception of older adults; technological and other

implementation aspects as capabilities for SAR adoption and economic value; and overcoming social and psychological barriers in aging through technology. The findings on the roles of SARs and the research topics on SARs for older adults can be considered complementary. While the identified main roles offer insights into the potential benefits, the research topics indicate the potential challenges of the SAR technology implementation. These research results offer practical implications for policymakers, the leadership of health and social care institutions, non-government organizations representatives, and other stakeholders involved in the design and production of technological solutions for the aging population. Improved understanding of the roles and research topics related to SARs would allow various stakeholders to have more informed discussions about the potential benefits and challenges of using SARs in enhancing the independence of older adults living both at home and in long-term care facilities. Regarding the limitations of this study, since only review articles were included in the content analysis, we recognize that the inclusion of original research studies could result in the identification of additional specific roles of SARs. To further inform policymakers and other stakeholders at the local and state levels, we recommend that future research focus on examining country-specific ethical, legal, and technical factors related to the potential use of SARs in elderly care. Exploring the attitudes and real needs of older adults is essential to ensure that their well-being is prioritized when implementing SAR technology.

## Acknowledgments

This research has been conducted within the project "Senior 2030 - Thematic Network for Active Ageing Policy in Croatia" funded by the European Social Fund.

## References

- Abdi, J., Al-Hindawi, A., Ng, T., & Vizcaychipi, M. P. (2018). Scoping review on the use of socially assistive robot technology in elderly care. *BMJ Open*, 8(2), e018815, 1-21. DOI: 10.1136/bmjopen-2017-018815
- Abou Allaban, A., Wang, M., & Padir, T. (2020). A systematic review of robotics research in support of in-home care for older adults. *Information*, 11(2), 75, 1-23. DOI: 10.3390/info11020075
- Bonaccorsi, M., Fiorini, L., Cavallo, F., Saffiotti, A., & Dario, P. (2016). A cloud robotics solution to improve social assistive robots for active and healthy aging. *International Journal of Social Robotics*, 8(3), 393-408. DOI: 10.1007/s12369-016-0351-1
- Budak, K. B., Atefi, G., Hoel, V., Laporte Uribe, F., Meiland, F., Teupen, S., Felding, S. A., & Roes, M. (2021). Can technology impact loneliness in dementia? A scoping review on the role of assistive technologies in delivering psychosocial interventions in long-term care. *Disability and Rehabilitation: Assistive Technology*, 1-13. DOI: 10.1080/17483107.2021.1984594
- Campos Antunes, T. P., Bulle de Oliveira, A. S., Hudec, R., Crocetta, T. B., Ferreira de Lima Antao, J. Y., de Almeida Barbosa, R. T., Guarnieri, R., Massetti, T., Garner, D.M., & de Abreu, L. C. (2019). Assistive technology for communication of older adults: a systematic review. *Ageing & Mental Health*, 23(4), 417-427. DOI: 10.1080/13607863.2018.1426718
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285-296. DOI: 10.1016/j.jbusres.2021.04.070
- European Commission. (2020). *The 2021 Ageing Report: Underlying Assumptions and Projection Methodologies*. Retrieved from: [https://ec.europa.eu/info/sites/default/files/economy-finance/ip142\\_en.pdf](https://ec.europa.eu/info/sites/default/files/economy-finance/ip142_en.pdf) (accessed on February 2, 2022).
- Feil-Seifer, D., & Mataric, M. J. (2005, June). Defining socially assistive robotics. In *9th International Conference on Rehabilitation Robotics, ICORR 2005.*, pp. 465-468. Retrieved from: <https://arl.human.cornell.edu/879Readings/Feilseifer.pdf> (accessed on February 3, 2022).
- Franke, A., Nass, E., Piereth, A. K., Zettl, A., & Heidl, C. (2021). Implementation of assistive technologies and robotics in long-term care facilities: A three-stage assessment based on acceptance, ethics, and emotions. *Frontiers in Psychology*, 12:694297, 1-13. DOI: 10.3389/fpsyg.2021.694297

- Gasteiger, N., Loveys, K., Law, M., & Broadbent, E. (2021). Friends from the future: A scoping review of research into robots and computer agents to combat loneliness in older people. *Clinical Interventions in Aging*, 16, 941-971. DOI: 10.2147/CIA.S282709
- Gerling, K., Hebesberger, D., Dondrup, C., Körtner, T., & Hanheide, M. (2016). Robot deployment in long-term care. *Zeitschrift für Gerontologie und Geriatrie*, 49(4), 288-296. DOI: 10.1007/s00391-016-1065-6
- Getson, C., & Nejat, G. (2021). Socially assistive robots helping older adults through the pandemic and life after COVID-19. *Robotics*, 10(3), 106, 1-23. DOI: 10.3390/robotics10030106
- Ghafurian, M., Hoey, J., & Dautenhahn, K. (2021). Social robots for the care of persons with dementia: A systematic review. *ACM Transactions on Human-Robot Interaction*, 10(4), 1-31. DOI: 10.1145/3469653
- Gongora Alonso, S., Hamrioui, S., de la Torre Diez, I., Motta Cruz, E., López-Coronado, M., & Franco, M. (2019). Social robots for people with aging and dementia: A systematic review of literature. *Telemedicine and e-Health*, 25(7), 533-540. DOI: 10.1089/tmj.2018.0051
- Hirt, J., Ballhausen, N., Hering, A., Kliegel, M., Beer, T., & Meyer, G. (2021). Social robot interventions for people with dementia: A systematic review on effects and quality of reporting. *Journal of Alzheimer's Disease*, 79(2), 773-792. DOI: 10.3233/JAD-200347
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277-1288. DOI: 10.1177/1049732305276687
- Ienca, M., Wangmo, T., Jotterand, F., Kressig, R. W., & Elger, B. (2018). Ethical design of intelligent assistive technologies for dementia: A descriptive review. *Science and Engineering Ethics*, 24(4), 1035-1055. DOI: 10.1007/s11948-017-9976-1
- Kang, H. S., Makimoto, K., Konno, R., & Koh, I. S. (2020). Review of outcome measures in PARO robot intervention studies for dementia care. *Geriatric Nursing*, 41(3), 207-214. DOI: 10.1016/j.gerinurse.2019.09.003
- Khosravi, P., & Ghapanchi, A. H. (2016). Investigating the effectiveness of technologies applied to assist seniors: A systematic literature review. *International Journal of Medical Informatics*, 85(1), 17-26. DOI: 10.1016/j.ijmedinf.2015.05.014
- Koh, W. Q., Ang, F. X. H., & Casey, D. (2021). Impacts of low-cost robotic pets for older adults and people with dementia: Scoping review. *JMIR Rehabilitation and Assistive Technologies*, 8(1), e25340, 1-14. DOI: 10.2196/25340
- Kruse, C. S., Fohn, J., Umunnakwe, G., Patel, K., & Patel, S. (2020, September). Evaluating the facilitators, barriers, and medical outcomes commensurate with the use of assistive technology to support people with dementia: A systematic review literature. *Healthcare*, 8(3), 278, 1-44. DOI: 10.3390/healthcare8030278
- Langer, A., Feingold-Polak, R., Mueller, O., Kellmeyer, P., & Levy-Tzedek, S. (2019). Trust in socially assistive robots: Considerations for use in rehabilitation. *Neuroscience & Biobehavioral Reviews*, 104, 231-239. DOI: 10.1016/j.neubiorev.2019.07.014
- Lu, L. C., Lan, S. H., Hsieh, Y. P., Lin, L. Y., Lan, S. J., & Chen, J. C. (2021). Effectiveness of companion robot care for dementia: A systematic review and meta-analysis. *Innovation in Aging*, 5(2), 1-29. DOI: 10.1093/geroni/igab013
- 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, 1-23. DOI: 10.3389/fninf.2019.00058
- Mansouri, N., Goher, K., & Hosseini, S. E. (2017). Ethical framework of assistive devices: review and reflection. *Robotics and Biomimetics*, 4(1), 1-9. DOI: 10.1186/s40638-017-0074-2
- Martinez-Martin, E., Escalona, F., & Cazorla, M. (2020). Socially assistive robots for older adults and people with autism: An overview. *Electronics*, 9(2), 367, 1-17. DOI: 10.3390/electronics9020367
- Mois, G., & Beer, J. M. (2020). The role of healthcare robotics in providing support to older adults: A socio-ecological perspective. *Current Geriatrics Reports*, 9(2), 82-89. DOI: 10.1007/s13670-020-00314-w
- Mois, G., & Fortuna, K. L. (2020). Visioning the future of gerontological digital social work. *Journal of Gerontological Social Work*, 63(5), 412-427. DOI: 10.1080/01634372.2020.1772436
- 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. DOI: 10.1017/S1041610217001776
- Okoli, C. (2015). A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, 37(1), 43. DOI: 10.17705/1CAIS.03743
- Papadopoulos, I., Koulouglioti, C., & Ali, S. (2018). Views of nurses and other health and social care workers on the use of assistive humanoid and animal-like robots in health and social care: A scoping review. *Contemporary Nurse*, 54(4-5), 425-442. DOI: 10.1080/10376178.2018.1519374
- Papadopoulos, I., Koulouglioti, C., Lazzarino, R., & Ali, S. (2020). Enablers and barriers to the implementation of socially assistive humanoid robots in health and social care: a systematic review. *BMJ Open*, 10(1), e033096, 1-13. DOI: 10.1136/bmjopen-2019-033096

- Piau, A., Campo, E., Rumeau, P., Vellas, B., & Nourhashemi, F. (2014). Aging society and gerontechnology: A solution for an independent living? *The Journal of Nutrition, Health & Aging*, 18(1), 97-112. DOI: 10.1007/s12603-013-0356-5
- Pu, L., Moyle, W., Jones, C., & Todorovic, M. (2019). The effectiveness of social robots for older adults: a systematic review and meta-analysis of randomized controlled studies. *The Gerontologist*, 59(1), 37-51. DOI: 10.1093/geront/gny046
- Qiu, S., An, P., Kang, K., Hu, J., Han, T., & Rauterberg, M. (2021). Investigating socially assistive systems from system design and evaluation: A systematic review. *Universal Access in the Information Society*, 1-25. DOI: 10.1007/s10209-021-00852-w
- Rantanen, T., Lehto, P., Vuorinen, P., & Coco, K. (2018). Attitudes towards care robots among Finnish home care personnel—a comparison of two approaches. *Scandinavian Journal of Caring Sciences*, 32(2), 772– 782. DOI:10.1111/scs.12508
- Satalkina, L., & Steiner, G. (2020). Digital entrepreneurship and its role in innovation systems: A systematic literature review as a basis for future research avenues for sustainable transitions. *Sustainability*, 12(7), 2764, 1-27. DOI: 10.3390/su12072764
- Tan, S. Y., Taeliagh, A., & Tripathi, A. (2021). Tensions and antagonistic interactions of risks and ethics of using robotics and autonomous systems in long-term care. *Technological Forecasting and Social Change*, 167: 120686. DOI: 10.1016/j.techfore.2021.120686
- Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207-222. DOI: 10.1111/1467-8551.00375
- United Nations. (2020). *World Population Ageing 2020 Highlights*. Retrieved from: [https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/files/documents/2020/September/un\\_pop\\_2020\\_pf\\_ageing\\_10\\_key\\_messages.pdf](https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/files/documents/2020/September/un_pop_2020_pf_ageing_10_key_messages.pdf) (accessed on February 4, 2022).
- Vandemeulebroucke, T., de Casterlé, B. D., & Gastmans, C. (2018). How do older adults experience and perceive socially assistive robots in aged care: a systematic review of qualitative evidence. *Aging & Mental Health*, 22(2), 149-167. DOI: 10.1080/13607863.2017.1286455
- Vandemeulebroucke, T., Dzi, K., & Gastmans, C. (2021). Older adults' experiences with and perceptions of the use of socially assistive robots in aged care: A systematic review of quantitative evidence. *Archives of Gerontology and Geriatrics*, 95, 104399, 1-14. DOI: 10.1016/j.archger.2021.104399
- World Economic Forum. (2021). *Ageing: Looming crisis or booming opportunity?* Retrieved from: <https://www.weforum.org/agenda/2021/03/ageing-looming-crisis-or-booming-opportunity/> (accessed on February 4, 2022).
- World Health Organization. (2018). *Improving Access to Assistive Technology*. Retrieved from: [https://apps.who.int/gb/ebwha/pdf\\_files/WHA71/A71\\_21-en.pdf](https://apps.who.int/gb/ebwha/pdf_files/WHA71/A71_21-en.pdf) (accessed on February 4, 2022).
- Yuan, F., Klavon, E., Liu, Z., Lopez, R. P., & Zhao, X. (2021). A systematic review of robotic rehabilitation for cognitive training. *Frontiers in Robotics and AI*, 8:605715, 1-24. DOI: 10.3389/frobt.2021.605715
- Zafrani, O., & Nimrod, G. (2019). Towards a holistic approach to studying human–robot interaction in later life. *The Gerontologist*, 59(1), 26-36. DOI: 10.1093/geront/gny077