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RESEARCH ARTICLE

Mapping the Evolution Human-Centered Care Robotics: A Bibliometric and Thematic Analysis of Socially Assistive Robotics Research

YONG SOON SHIN^{ID} AND MI YOUNG KIM^{ID}

College of Nursing, Research Institute of Nursing Science, Hanyang University, Seongdong-gu, Seoul 04763, Republic of Korea

Corresponding author: Mi Young Kim (miyoung0@hanyang.ac.kr)

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ABSTRACT The rapid aging of populations and increasing demand for long-term care have accelerated the development of care robotics. Despite substantial growth in the field, its intellectual structure and thematic evolution remain poorly understood. This study aimed to systematically map the development of care robotics research through a bibliometric analysis. A total of 3,062 publications indexed in the Web of Science Core Collection between 1993 and January 23, 2026, were analyzed using Bibliometrix and VOSviewer. We examined publication trends, country productivity, publication sources, keyword co-occurrence networks, and thematic structures. The results revealed a significant increase in research activity, with an annual growth rate of 9.33%. The United States was the leading contributor, followed by China, Italy, and Japan. Keyword analyses identified social robots, older adults, human–robot interaction, dementia, and socially assistive robots as the dominant research topics. Co-occurrence analysis demonstrated strong connections between the technological, healthcare, and psychosocial dimensions of care robotics. Thematic mapping identified people, speech, and care as motor themes, whereas technology, socially assistive robots, and acceptance emerged as foundational themes. Social robots, older adults, and human–robot interactions appeared as evolving themes, indicating increasing specialization within the field. These findings suggest that care robotics research has evolved from a technology-driven field to a more human-centered and application-oriented discipline. This study provides insights for future research, technology development, and implementation strategies in healthcare and aging societies.

INDEX TERMS Care robotics, social robots, human–robot interaction, older adults, bibliometric analysis, thematic analysis.

I. INTRODUCTION

The global demographic landscape is undergoing unprecedented transformation, characterized by rapid population aging. According to the latest projections from the World Health Organization [1], the number of people aged ≥ 60 years is expected to double to 2.1 billion by 2050. This demographic shift represents one of the most significant challenges, fundamentally reshaping healthcare systems and social welfare structures across nations [1], [2].

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Furthermore, projections from the Global Burden of Disease Study 2019 estimate that the number of people living with dementia worldwide will increase from 57.4 million in 2019 to 152.8 million by 2050, primarily driven by population growth and aging, underscoring the urgent need for sustainable care models and innovative technological interventions [3].

These demographic pressures have intensified the strain on health care systems worldwide, particularly in long-term care. At the same time, many countries are experiencing critical shortages in professional caregivers, with demand projected to substantially outpace supply in the coming decades [4].

In response to these converging challenges, care robotics has emerged as a rapidly advancing multidisciplinary field that integrates robotics, artificial intelligence, human–computer interaction, and gerontology to develop innovative solutions to support older adults, individuals with disabilities, and their caregivers.

Care robots encompass a diverse category of robotic systems designed to assist individuals with needs arising from ageing, disability, chronic illness, or functional limitations. This broad classification includes assistive robots that support activities of daily living, social robots that provide companionship and emotional engagement, rehabilitation robots that facilitate physical recovery, service robots that perform household tasks, and monitoring robots that track health status and detect emergencies [5]. These systems range from socially assistive robots designed to enhance cognitive stimulation and emotional well-being to physically assistive robots that support mobility, feeding, and bathing [6]. Although early prototypes emerged in the 1990s, the field has accelerated significantly in recent years owing to advances in sensor technologies, machine learning, natural language processing, and human–robot interaction designs [7]. No examples include PARO, a therapeutic seal robot widely used in dementia care; Pepper and NAO, humanoid robots for social engagement and education; and robotic mobility aids that promote independence among individuals with physical impairments [8].

Despite the rapid expansion of research and technological development, this field lacks comprehensive bibliometric analysis that systematically maps its intellectual structure, identifies key contributors and collaborative networks, traces thematic evolution, and highlights emerging research frontiers.

Bibliometric analysis quantitatively examines publication metadata to identify influential publications, research trends, collaboration networks, and thematic structures within a research field [9]. As a quantitative research methodology, bibliometric analysis facilitates the mapping of intellectual structures, developmental trajectories, and research impacts through the application of statistical and computational techniques to bibliographic data [10]. This approach is particularly valuable for rapidly evolving, multidisciplinary fields such as care robotics, where the volume and diversity of literature present significant challenges for comprehensive synthesis using conventional methods.

Although several recent bibliometric studies have explored related domains, including social robotics [9], [11], robotic technology for older adults [12], and global nursing robotics [13], [14], these analyses have primarily focused on specific subfields. To date, no study has provided a comprehensive bibliometric examination of the broader care robotics ecosystem encompassing assistive, social, rehabilitation, monitoring, and service robots across the healthcare and long-term care contexts. Furthermore, existing studies have generally been limited in scope, focusing on particular application

areas rather than on capturing the intellectual structure, thematic evolution, and collaborative landscape of care robotics research as a whole. This study addresses this gap by providing a comprehensive analysis of care robotics research conducted from 1993 to January 23, 2026.

This study makes three primary contributions to the literature on care robotics: First, it provides the most comprehensive bibliometric overview of care robotics research spanning more than three decades from 1993 to January 23, 2026. Second, it integrates publication, citation, collaboration, and thematic analyses to reveal the field's intellectual structure and developmental trajectory. Third, it identifies emerging research themes and knowledge gaps that may inform future research, policy development, and the clinical implementation of care robotics. The objectives of this study were to (1) characterize publication trends and growth patterns; (2) examine the intellectual and collaborative structure of the field through citation, country, and source analyses; (3) identify major thematic clusters, keyword networks, and emerging research topics; and (4) explore the implications for future research, policy development, and clinical implementation.

The remainder of this paper is organized as follows. Section II describes the data sources and bibliometric methods used. Section III presents the results of publication, collaboration, and thematic analyses. Section IV discusses the major findings and implications. Finally, Section V concludes the paper and outlines directions for future research.

II. METHODS

A. STUDY DESIGN

This study conducted a bibliometric analysis combined with visual knowledge mapping to systematically examine the intellectual structure and thematic evolution of care robotics. Bibliometric analysis is a quantitative research method that applies statistical and mathematical techniques to identify patterns in scientific publications, including authorship, citation networks, keyword distributions, and institutional affiliations [9].

Visual knowledge mapping complements bibliometric analysis by generating network-based visualizations that reveal collaborative relationships, conceptual structures, and thematic clusters within a research domain [9]. The integration of these approaches has enabled comprehensive and data-driven understanding of the development, structure, and dynamics of care robotics.

B. DATA SOURCE AND SEARCH STRATEGY

The WoS Core Collection was selected as the primary data source. WoS is widely recognized as a comprehensive and authoritative multidisciplinary database that indexes high-quality peer-reviewed publications across the sciences, social sciences, and humanities [11], [15]. Its rigorous indexing standards, standardized citation data, and advanced search

functionalities make it particularly suitable for bibliometric analyses [16].

The search strategy was designed to identify publications related to care robots in the context of care for older adults, disability support, and patient assistance. A literature search was performed in the WoS Core Collection on January 23, 2026, using the following search query:

TS = ((“care* robot*” OR “assistive robot*” OR “social robot*” OR “healthcare robot*” OR “nurs* robot*” OR “companion robot*”) AND (“elder*” OR “older adult*” OR “senior*” OR “aged” OR “disabled” OR “disability” OR “patient*”))

Boolean operators and wildcard characters were used to maximize retrieval sensitivity, while maintaining specificity. The “TS” field searches titles, abstracts, author keywords, and Keywords Plus. No restrictions were imposed on publication type, language, or time period to ensure comprehensive coverage of the field.

C. INCLUSION AND EXCLUSION CRITERIA

The initial search yielded 3,151 records that were screened using a modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram approach. All screening procedures were conducted independently by two reviewers to enhance the reliability and consistency of the selection process. Eight duplicate records were identified using WoS tools and manual verification and subsequently removed. In addition, two records without abstracts were excluded because they were required to assess topical relevance. The remaining 3,141 records were screened for eligibility based on their relevance to care robotics. Following the screening process, a final dataset of 3,062 publications published between 1993 and January 23, 2026, was retained for analysis (Figure 1).

D. ANALYTICAL TOOLS

Three complementary software tools were used for data processing, analysis, and visualization. Microsoft Excel was used for initial data cleaning, organization, and descriptive statistical analysis. Bibliographic data exported from WoS were processed to standardize author names, institutional affiliations, and country information.

VOSviewer (version 1.6.20) was used for network and cluster analyses. VOSviewer is a widely used tool for constructing and visualizing bibliometric networks, including co-authorship, keyword co-occurrence, and citation networks [16]. In this study, keyword analyses were performed using all keywords extracted from the dataset, including both the authors’ keywords (DE) and Keywords Plus (ID). Word clouds and keyword co-occurrence networks were generated using all keywords with a minimum threshold of five occurrences. The clustering algorithm identified thematic clusters based on the keyword co-occurrence strength, and the resulting networks were visualized using a force-directed layout

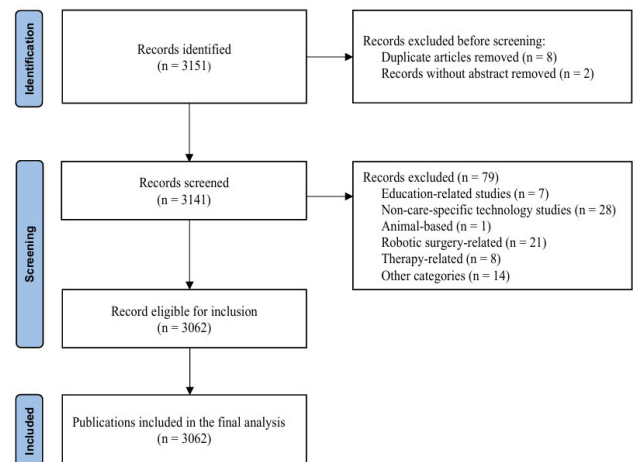


FIGURE 1. Flow diagram of the literature selection and screening processes.

in which closely related keywords were positioned in close proximity.

RStudio with the bibliometrix package was used for the bibliometric analysis. Bibliometrix is an open-source R package developed for science mapping and bibliometric research [17], [18]. In this study, descriptive statistics were generated, including publication trends, country productivity, journal performance, and keyword frequencies.

E. ETHICAL CONSIDERATIONS

This study involved a secondary analysis of publicly available bibliographic data, and did not include human participants, animal subjects, or protected health information. Therefore, institutional review board approval was not required for this study. All data were obtained from the WoS database in accordance with institutional licensing agreements and analyzed in aggregate form without identifying individual participants or patients described in the source publications.

III. RESULTS

A. GENERAL CHARACTERISTICS OF THE DATASET

Table 1 summarizes the bibliometric characteristics of the Care Robotics dataset. The final dataset comprised 3,062 publications from 1,381 sources, published between 1993 and January 23, 2026. The annual growth rate was 9.33%, with an average document age of 6.01 years and 17.63 citations per document. A total of 9,267 authors contributed to the dataset, with an average of 4.89 co-authors per document and an international co-authorship rate of 23.61%.

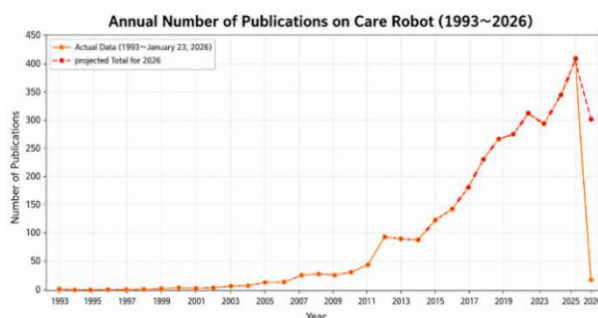
B. ANNUAL PUBLICATION TRENDS

Figure 2 shows the annual publication trends in care robotics research from 1993 to January 2026. Overall, publication output has increased substantially over time, rising from a single publication in 1993 to 409 publications in 2025.

For descriptive purposes, publication trends were categorized into four phases: emergence (1993–2007), initial growth

TABLE 1. Bibliometric characteristics of the care robotics dataset.

Description	Results
Main data information	
Timespan	1993–January 23, 2026
Sources (journals, proceedings, and other publications)	1381
Documents	3062
Annual growth rate (%)	9.33
Average document age	6.01
Average citations per document	17.63
References	79856
Document contents	
Keywords plus (ID)	2083
Authors' keywords (DE)	5883
Authors	
Authors	9267
Authors of single-authored documents	134
Author collaborations	
Single-authored documents	150
Coauthors per document	4.89
International co-authorships (%)	23.61

**FIGURE 2. Annual scientific production in care robotics research.**

(2008–2012), acceleration (2013–2019), and rapid expansion (2020–2025).

1) PHASE 1 (1993-2007): EMERGENCE

The earliest publication of this dataset was in 1993. Research activity remained limited during this period, with annual publication counts generally remaining in single digits or low double-digits. A total of 46 publications (1.5% of the dataset) were published during this phase.

2) PHASE 2 (2008-2012): INITIAL GROWTH

Research output increased during this period, reaching 44 publications in 2012. A total of 171 publications were published between 2008 and 2012, indicating the beginning of a sustained growth in care robotics research.

3) PHASE 3 (2013-2019): ACCELERATION

The publication output increased markedly from 92 publications in 2013 to 232 in 2019. This phase accounted for 1,074 publications and represented a period of accelerated growth.

4) PHASE 4 (2020-2025): RAPID EXPANSION

The most pronounced growth occurred during this period, with the annual publication output increasing from 267 publications in 2020 to 409 publications in 2025, the highest annual count in the dataset. A total of 1,752 publications were produced during this phase, accounting for 57.2% of all the publications included in the analysis.

The data for 2026 were incomplete because the literature search was conducted on January 23, 2026. Therefore, publications indexed after the search date were excluded from the dataset.

C. COUNTRY-LEVEL RESEARCH PRODUCTIVITY AND COLLABORATION

Table 2 presents the top 10 countries based on the corresponding authors' publications in care robotics research. The United States ranked first, with 451 publications (14.9%), followed by China (301 publications, 10.0%), Italy (234 publications, 7.8%), and Japan (232 publications, 7.7%). Together, these four countries account for approximately 40.4% of the total publications in the dataset.

TABLE 2. Top 10 countries by corresponding author publications.

Rank	Country	Articles	Share (%)	SCP	MCP	MCP RATIO
1	USA	451	14.9	405	46	0.102
2	China	301	10.0	222	79	0.262
3	Italy	234	7.8	162	72	0.308
4	Japan	232	7.7	189	43	0.185
5	Germany	182	6.0	140	42	0.231
6	United Kingdom	176	5.8	102	74	0.420
7	Spain	132	4.4	111	21	0.159
8	Canada	130	4.3	104	26	0.200
9	South Korea	125	4.1	103	22	0.176
10	Netherlands	109	3.6	86	23	0.211

Note. SCP: Single-country publications (intra-country collaboration); MCP: Multiple-country publications (international collaboration); MCP Ratio: Proportion of multiple-country publications among total publications for each country.

In terms of collaboration patterns, the United States produced the highest number of single-country publications. (SCP=405), indicating a strong domestic research activity. China (MCP=79), the United Kingdom (MCP=74), and Italy (MCP=72) have demonstrated relatively high levels of international collaboration. The United Kingdom exhibited the highest MCP ratio (0.420), suggesting that nearly half of its publications involved international co-authorship. In contrast, the United States showed a relatively low MCP ratio (0.102), indicating that most publications were produced through domestic collaboration.

increasingly integrated into themes, such as socially assistive robotics, technology acceptance, and AI-enabled care applications.

Recent studies suggest that care robotics research has increasingly shifted toward socially assistive robotics and human-centered applications that emphasize user acceptance, trust, social engagement, and quality of life among older adults [21], [22], [23]. This trend supports the interpretation that foundational themes are being refined into more specialized and application-oriented research areas rather than declining in importance.

The thematic map further reveals an important transition in the field. While people, speech, and care emerged as motor themes, technology, socially assistive robots, and acceptance were identified as basic themes that formed the conceptual foundation of contemporary care robotics research. While the technical core remains grounded in assistive and rehabilitation robotics, the increasing prominence of clusters addressing the social, psychological, and clinical dimensions indicates a clear shift toward human-centered research. This transition aligns with broader developments in human–robot interaction, emphasizing the importance of designing technologies that address not only physical needs but also emotional and social well-being [6].

Integrating ethics and artificial intelligence is a critical frontier. Recent studies have increasingly emphasized ethical considerations related to autonomy, dignity, privacy, and the appropriate use of robots in care contexts [24]. As advanced artificial intelligence technologies, such as large language models, have become integrated into care robots, these ethical considerations are becoming increasingly urgent, particularly in relation to transparency, trust, and the preservation of human relationships [12], [24].

In addition, the growing focus on caregiver support and technology acceptance highlights the importance of sociotechnical factors for successful implementation. Care robots are not used in isolation but operate within complex care systems involving multiple stakeholders. Acceptance by caregivers, both formal and informal, plays a critical role in determining adoption and sustained use, emphasizing the need for user-centered design and implementation strategies [25].

Increasing attention on social isolation has underscored the role of care robots in supporting psychosocial well-being. Although robots cannot replace human relationships, they can complement them by facilitating communication and providing companionship to socially isolated individuals [26]. Similarly, the focus on dementia care reflects the urgent need for nonpharmacological interventions, with robotic systems offering the potential to improve quality of life and reduce behavioral symptoms [27].

Overall, these findings indicate that care robot research is undergoing a paradigm shift from technology-driven development to an integrated, human-centered, and care-oriented approach. Future research should prioritize the integration of technological innovation with ethical, social, and

clinical considerations to support the sustainable and responsible deployment of care robots.

This study has several limitations. First, the reliance on the WoS database may have excluded relevant studies indexed elsewhere. Second, the partial inclusion of 2026 data constrains the interpretation of trends. Finally, bibliometric analysis cannot assess the quality or real-world effectiveness of individual studies, thus highlighting the need for complementary, systematic, and empirical research.

V. CONCLUSION

This study provides a comprehensive bibliometric overview of care robotics research from 1993 to January 23, 2026, revealing substantial growth and increasing interdisciplinary engagement in the field. These findings indicate that care robotics has evolved from a predominantly technology-driven domain into a more human-centered and application-oriented area of research.

Keyword, co-occurrence, and thematic analyses identified social robots, older adults, dementia care, and human–robot interaction as major research topics. Notably, while social robots, older adults, and human–robot interactions remain central themes, they appear to evolve into more specialized domains, including socially assistive robotics, technology acceptance, and AI-enabled care applications. These findings suggest a shift from foundational conceptual discussions to implementation-focused and user-centered research.

This study also revealed the geographic concentration of research activity in a small number of leading countries and highlighted the importance of international collaboration in advancing the field. From a practical perspective, the identified trends may inform the development of user-centered care technologies, research agendas, educational programs, and implementation strategies.

Future research should strengthen interdisciplinary collaboration and evaluate the real-world effectiveness, acceptability, and ethical implications of care robots across diverse settings. Ultimately, the sustainable advancement of care robotics depends on aligning technological innovation with human needs, social contexts, and quality care delivery.

Several open research questions emerged from this study. Future research should investigate how care robots can be effectively integrated into real-world healthcare and long-term care environments, identify the factors influencing long-term user acceptance and trust, and evaluate the clinical and economic effectiveness of care robotics interventions. Further research is needed to address the ethical, privacy, and governance challenges associated with AI-enabled care robots and to promote equitable adoption across diverse cultural and healthcare settings.

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revised, and verified by the authors, who take full responsibility for the integrity and accuracy of the manuscript.

REFERENCES

- [1] World Health Organization. (2024). *Ageing and Health: Key Facts*. Accessed: Apr. 25, 2026. [Online]. Available: <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>
- [2] United Nations, Department of Economic and Social Affairs, Population Division. (2024). *World Population Prospects 2024: Summary of Results*. UN Rep. Accessed: Apr. 25, 2026. [Online]. Available: <https://population.un.org/wpp/>
- [3] E. Nichols, "Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: An analysis for the global burden of disease study 2019," *Lancet Public Health*, vol. 7, no. 2, pp. e105–e125, Feb. 2022, doi: [10.1016/s2468-2667\(21\)00249-8](https://doi.org/10.1016/s2468-2667(21)00249-8).
- [4] E. G. Christoforou, S. Avgousti, N. Ramdani, C. Novales, and A. S. Panayides, "The upcoming role for nursing and assistive robotics: Opportunities and challenges ahead," *Frontiers Digit. Health*, vol. 2, Dec. 2020, Art. no. 585656, doi: [10.3389/fdgh.2020.585656](https://doi.org/10.3389/fdgh.2020.585656).
- [5] J. Abdi, A. Al-Hindawi, T. Ng, and M. P. Vizcaychipi, "Scoping review on the use of socially assistive robot technology in elderly care," *BMJ Open*, vol. 8, no. 2, Feb. 2018, Art. no. e018815, doi: [10.1136/bmjopen-2017-018815](https://doi.org/10.1136/bmjopen-2017-018815).
- [6] E. Broadbent, "Interactions with robots: The truths we reveal about ourselves," *Annu. Rev. Psychol.*, vol. 68, no. 1, pp. 627–652, Jan. 2017, doi: [10.1146/annurev-psych-010416-043958](https://doi.org/10.1146/annurev-psych-010416-043958).
- [7] L. Cui, Y. Li, X. Yang, X. Liu, L. Zhang, and L. Hou, "Humanoid robot-assisted support for health care in older adults: Systematic scoping review," *JMIR Aging*, vol. 9, Mar. 2026, Art. no. e83849, doi: [10.2196/83849](https://doi.org/10.2196/83849).
- [8] D. Zhao, X. Sun, B. Shan, Z. Yang, J. Yang, H. Liu, Y. Jiang, and Y. Hiroshi, "Research status of elderly-care robots and safe human-robot interaction methods," *Frontiers Neurosci.*, vol. 17, Nov. 2023, Art. no. 1291682, doi: [10.3389/fnins.2023.1291682](https://doi.org/10.3389/fnins.2023.1291682).
- [9] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, Sep. 2021, doi: [10.1016/j.jbusres.2021.04.070](https://doi.org/10.1016/j.jbusres.2021.04.070).
- [10] B. Wang, S. Cao, W. Qi, X. Zhu, D. He, and Y. Chen, "A scientometric review of robotics in elderly care: Hotspots and emerging trends analysis (2003–2023)," in *Proc. 4th Int. Symp. Artif. Intell. Med. Sci.*, 2023, pp. 568–573, doi: [10.1145/3644116.3644210](https://doi.org/10.1145/3644116.3644210).
- [11] M. J. S. Dino, P. M. Davidson, K. W. Dion, S. L. Szanton, and I. L. Ong, "Nursing and human-computer interaction in healthcare robots for older people: An integrative review," *Int. J. Nursing Stud. Adv.*, vol. 4, Dec. 2022, Art. no. 100072, doi: [10.1016/j.ijnsa.2022.100072](https://doi.org/10.1016/j.ijnsa.2022.100072).
- [12] J. Li and H. Wang, "The evolution of research on robotic technology for older adults: A bibliometric analysis," in *Proc. AHFE Int. Conf.*, vol. 4, 2025, pp. 80–90, doi: [10.54941/ahfe1006296](https://doi.org/10.54941/ahfe1006296).
- [13] S. Zhang, L. Liu, T. Peng, and S. Ding, "Patterns and trends in global nursing robotics research: A bibliometric study," *J. Nursing Manage.*, vol. 2025, no. 1, Jan. 2025, Art. no. 7853870, doi: [10.1155/jonm/7853870](https://doi.org/10.1155/jonm/7853870).
- [14] H. Carter-Templeton, R. M. Frazier, L. Wu, and T. H. Wyatt, "Robotics in nursing: A bibliometric analysis," *J. Nursing Scholarship*, vol. 50, no. 6, pp. 582–589, Nov. 2018, doi: [10.1111/jnu.12399](https://doi.org/10.1111/jnu.12399).
- [15] A. Kaya and G. N. Yildiz, "The evolution of publications on applications of artificial intelligence to nursing care: A bibliometric and visual mapping approach," *Nursing Outlook*, vol. 74, no. 1, Jan. 2026, Art. no. 102609, doi: [10.1016/j.outlook.2025.102609](https://doi.org/10.1016/j.outlook.2025.102609).
- [16] S. I. Abdelwahab, M. M. E. Taha, A. Farasani, J. M. Mosh, A. Assiri, S. Alshahrani, K. A. Sahli, H. M. Shubaily, M. Qadri, A. Khardali, and W. Hassan, "A bibliometric analysis of the top 100 most-cited articles published in the journal of robotic surgery," *J. Robotic Surgery*, vol. 20, no. 1, Dec. 2025, Art. no. 93, doi: [10.1007/s11701-025-03056-z](https://doi.org/10.1007/s11701-025-03056-z).
- [17] M. Aria and C. Cuccurullo, "Bibliometrix: An R-tool for comprehensive science mapping analysis," *J. Informetrics*, vol. 11, no. 4, pp. 959–975, Nov. 2017, doi: [10.1016/j.joi.2017.08.007](https://doi.org/10.1016/j.joi.2017.08.007).
- [18] T. Bagdi, S. Ghosh, A. Sarkar, A. K. Hazra, S. Balachandran, and S. Chaudhury, "Evaluation of research progress and trends on gender and renewable energy: A bibliometric analysis," *J. Cleaner Prod.*, vol. 423, Oct. 2023, Art. no. 138654, doi: [10.1016/j.jclepro.2023.138654](https://doi.org/10.1016/j.jclepro.2023.138654).
- [19] S. A. Olatunji, V. Falcon, A. Ramesh, and W. A. Rogers, "Considerations for designing socially assistive robots for older adults," *Frontiers Robot. AI*, vol. 12, Oct. 2025, Art. no. 1622206, doi: [10.3389/frobt.2025.1622206](https://doi.org/10.3389/frobt.2025.1622206).
- [20] F. Ferrari, S. Divan, C. Guerrero, F. Zenatti, R. Guidolin, L. Palopoli, and D. Fontanelli, "Human–robot interaction analysis for a smart Walker for elderly: The ACANTO interactive guidance system," *Int. J. Social Robot.*, vol. 12, no. 2, pp. 479–492, May 2020, doi: [10.1007/s12369-019-00572-5](https://doi.org/10.1007/s12369-019-00572-5).
- [21] B. Irfan, S. Kuoppamäki, and G. Skantze, "Recommendations for designing conversational companion robots with older adults through foundation models," *Frontiers Robot. AI*, vol. 11, May 2024, Art. no. 1363713, doi: [10.3389/frobt.2024.1363713](https://doi.org/10.3389/frobt.2024.1363713).
- [22] F. Naseer, M. N. Khan, M. Tahir, A. Addas, and H. Kashif, "Enhancing elderly care with socially assistive robots: A holistic framework for mobility, interaction, and well-being," *IEEE Access*, vol. 13, pp. 82698–82717, 2025, doi: [10.1109/ACCESS.2025.3567331](https://doi.org/10.1109/ACCESS.2025.3567331).
- [23] J. Fan, L. C. Mion, L. Beuscher, A. Ullal, P. A. Newhouse, and N. Sarkar, "SAR-connect: A socially assistive robotic system to support activity and social engagement of older adults," *IEEE Trans. Robot.*, vol. 38, no. 2, pp. 1250–1269, Apr. 2022, doi: [10.1109/TRO.2021.3092162](https://doi.org/10.1109/TRO.2021.3092162).
- [24] S. Tamir, "Ethical governance of AI-based humanoid carebots: The case for ethics of techno-care," *Med., Health Care Philosophy*, vol. 29, no. 1, pp. 75–87, Mar. 2026, doi: [10.1007/s11019-025-10305-3](https://doi.org/10.1007/s11019-025-10305-3).
- [25] Y. L. Tsai, "Integrating assistive robots into professional caregivers' workflow in aging healthcare," in *Proc. Hum. Factors Ergon. Soc. Annu. Meeting*, vol. 69, 2025, pp. 1800–1804, doi: [10.1177/10711813251369864](https://doi.org/10.1177/10711813251369864).
- [26] H. Zeng, Y. Sheng, and J. Zhu, "Companion robots supporting the emotional needs of the elderly: Research trends and future directions," *Information*, vol. 16, no. 11, p. 948, Nov. 2025, doi: [10.3390/info16110948](https://doi.org/10.3390/info16110948).
- [27] J. C. Zölllick, S. Rössle, L. Kluy, A. Kuhlmeier, and S. Blüher, "Potenziale und Herausforderungen von sozialen Robotern für Beziehungen älterer Menschen: Eine Bestandsaufnahme mittels rapid review-potentials and challenges of social robots in relationships with older people: A rapid review of current debates," *Zeitschrift für Gerontologie und Geriatrie*, vol. 55, no. 4, pp. 298–304, Jul. 2022, doi: [10.1007/s00391-021-01932-5](https://doi.org/10.1007/s00391-021-01932-5).



YONG SOON SHIN received the M.S. and Ph.D. degrees in nursing from Hanyang University, Seoul, South Korea, in 2002 and 2007, respectively. She is currently a Professor with the College of Nursing, Hanyang University. She has been actively involved as a Principal Investigator in research projects on the real-world implementation of care robots and care burden analysis, supported by a grant from Korea Health Technology Research and Development Project through Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health and Welfare, Republic of Korea. Her research interests include care robotics, intelligent care technologies, gerontological nursing, and the implementation of human-centered digital health innovations, and human-centered healthcare technology development and implementation.



MI YOUNG KIM received the M.S. and Ph.D. degrees in nursing from Seoul National University, Seoul, South Korea, in 2010 and 2014, respectively. She is currently a Professor with the College of Nursing, Hanyang University, Seoul. Her research interests include psychosocial interventions, care robotics education, human-centered care robotics, and technology-integrated healthcare education.