



Research Article

Exploring the Social Value of Care Robots: Text Mining and Semantic Network Analysis

Yong Soon Shin, Hye-Young Jang,^{*} Jung-A. Kim, Min-Soo Kang

College of Nursing, Hanyang University, Seoul, South Korea

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SUMMARY

Purpose: This study aimed to explore the public discourse surrounding care robots and identify their potential social values.

Methods: Data related to care robots were collected from major Korean portal sites and social media between January 1, 2021, and December 31, 2023, using TEXTOM. Core keywords were extracted through text mining. Topic modeling and semantic network analysis using UCINET 6.0 were conducted to examine keyword associations and network structure. An analytic framework based on thematic integration was applied to synthesize the findings and derive social value domains.

Results: A total of 9724 keywords were extracted from 21,216 documents. High-frequency and central keywords included older adult, companion robot, business, service, and artificial intelligence. Topic modeling identified four major topics: (1) companion robots supporting care to bridge the care gap, (2) care robots leading new economic trends, (3) care robots supporting human care across various sectors, and (4) government-led expansion of social care through care robots. Eight clusters were identified through semantic network analysis. By applying the analytic framework, these clusters were systematically integrated with topic modeling results, and the social values associated with care robots were categorized into four domains: health, labor, economy, and innovation.

Conclusion: Care robots have the potential to go beyond functional support by addressing broader social challenges and contributing to care innovation. However, current discourse remains provider driven with limited public engagement. There is a need to enhance communication of care robots' social value and promote user-centered approaches in nursing and care practice.

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Introduction

The rapid increase in the global population of individuals with disabilities, alongside the aging demographic, has led to a significant rise in care needs [1]. Conversely, the healthcare sector faces personnel shortages due to heightened workloads, insufficient resources, and pervasive burnout [2]. Additionally, the decline in informal caregivers, attributed to increased societal participation by women and evolving family structures, has exacerbated the disparity between the supply and demand for care services, culminating in a care crisis [1]. In this context, care

robots have emerged as a promising alternative to mitigate existing care gaps [3].

A care robot is an autonomous device designed to offer physical, cognitive, and emotional support not only to older adults requiring assistance but also to professionals and caregivers involved in providing care [4]. Based on their functional attributes, care robots are categorized as assistive robots or social assistive robots [5]. Assistive robots facilitate nursing care and monitoring, thereby reducing caregiver fatigue and enhancing patient safety and work efficiency by assuming repetitive and physically demanding tasks [6]. This enables nurses to allocate more time to direct interaction and emotional care with patients, leading to improved communication quality between patients and nurses [7]. Meanwhile, social assistive robots mitigate loneliness and enhance the quality of life for care recipients by fostering emotional and social interactions while also alleviating caregiver burden by strengthening social connections with care providers [8]. According to Locsin's [9] "Technological Competency as Caring in Nursing," care robots are not merely technologies that replace the

Yong Soon Shin: <https://orcid.org/0000-0002-9854-9549>; Hye-Young Jang: <https://orcid.org/0000-0003-0934-7679>; Jung-A. Kim: <https://orcid.org/0000-0002-9732-9376>; Min-Soo Kang: <https://orcid.org/0009-0003-2225-7261>

^{*} Correspondence to: Hye-Young Jang, College of Nursing, Hanyang University, 222, Wangsimni-ro, Seongdong-gu, Seoul 04763, South Korea.

E-mail address: white0108@hanyang.ac.kr

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role of nurses but are perceived as technological partners that assist nurses in focusing on human-centered care by automating repetitive tasks. The deployment of these technologies fosters qualitative improvements in essential nursing outcomes such as patient safety, work efficiency, emotional support, and job satisfaction [9].

Beyond their functional roles in supporting care delivery, care robots are increasingly recognized as a novel paradigm in caregiving, integrating technological efficiency with humanistic values and thereby enhancing the quality and sustainability of care [10]. These developments should be perceived not merely as enhancements in performance but also as a transformative process that broadens the societal role of care robots and generates social value. Social value pertains to changes that foster the evolution of social structures and systems, thereby improving individuals' quality of life [10]. It serves as a crucial indicator that augments community welfare, human dignity, and social solidarity while concurrently affirming the sustainability and legitimacy of the organization [10]. Consequently, identifying the social value of care robots is imperative for determining the trajectory of their development and acceptance in the nursing domain, as well as for enriching the core principles of human-centered care.

However, previous research on care robots has predominantly focused on examining their technological features and services [3,11] or assessing their perceived effectiveness [12–15]. Consequently, these studies have been limited in their ability to identify the social value of care robots, such as the types of social transformations they may induce or the generation of sustainable outcomes. Given that care robots are on the cusp of entering the market [16], it is imperative to investigate how public discourse surrounding care robots is represented within online platforms and media. In this study, “public discourse” refers to the collective expressions, discussions, and narratives about care robots, as reflected in online platforms and media content. Through this exploration, it becomes possible to examine the social value that care robots generate [17]. To achieve this objective, text mining, a research method capable of identifying key keywords and topics akin to a fractal principle within big data [18], can be used.

Text mining is an analytical approach that extracts valuable information, knowledge, or patterns from unstructured text [19]. This method facilitates the identification of keywords and topics not only within existing research literature but also across extensive unstructured data sources such as social networks [20]. Topic modeling, a principal technique in text mining, statistically analyzes large text corpora to probabilistically extract primary topics within documents, thereby enabling the identification of keyword distributions and correlation structures for each topic [21]. Furthermore, semantic network analysis, which utilizes text mining results, is a technique that examines the semantic structure and associations within text by visualizing the co-occurrence relationships between words, based on social network analysis [22]. Owing to these characteristics, topic modeling and semantic network analysis are regarded as valuable methodologies for investigating trends and directions related to specific research topics [23]. Notably, using both methods concurrently facilitates the examination of the flow of knowledge by confirming the connections between topics extracted through topic modeling using semantic network analysis [23].

In this study, we analyze keywords and topics associated with care robots using text mining and semantic network analysis to examine public discourse. Based on this analysis, we aim to elucidate the social value that care robots may generate. The results of this study are expected to provide foundational data to inform the strategic implementation of care robots in future care environments.

Methods

Design

This study used an exploratory design using text mining and semantic network analysis to examine public discourse surrounding care robots and identify their potential social values.

Data sources

The data analyzed in this study comprised blog posts, comments, and news articles collected from major portal sites and social media platforms. The analyzed data covered the period from January 1, 2021, to December 31, 2023. Data were collected from domestic portal sites with high market share, as reported by InternetTrend (<http://www.internettrend.co.kr>), including Naver (Naver Corp., 58.8%), Google (31.4%), and Daum (4.9%). Facebook (16.7%) was also included as one of the most widely used social media platforms [24]. Instagram (48.6%), despite having the highest domestic social media usage, was excluded due to its primary focus on photo and video sharing [25], which does not align with the objectives of text-based analysis. In addition, microblogging platforms such as Twitter (currently X) were excluded because their short and rapidly generated posts often contain high levels of noise and limited contextual information, potentially reducing the reliability of text-based analysis [26].

Data collection

Data were collected from materials published between January 1, 2021, and December 31, 2023. This period was selected based on the initiation of government-led research and development initiatives aimed at addressing social challenges among vulnerable populations. In particular, this period coincided with the expansion of age-friendly service research and development projects and increased investment in care robot-related research and service model development [27].

Data were collected using TEXTOM (The IMC Inc., Daegu, South Korea) [28], with “care robot” as the primary search keyword. The data sources included Naver (Blog, News, Café, and Knowledge iN), Daum (Tistory, News, and Café), Google News, and Facebook posts and comments. Blogs, cafés, and social network services were included as they facilitate active sharing of opinions and discussions among users with shared interests [29], making them appropriate for capturing public discourse surrounding care robots. News articles were also included to reflect broader social awareness and public perspectives [30]. A total of 21,216 documents were collected, with a total data size of 11.51 MB.

Data analysis

The researchers followed a comprehensive consensus-based approach to ensure proper data collection and analysis reliability. First, through three rounds of consensus meetings, the researchers established analysis criteria based on the collected data. This process aimed to maintain data interpretation consistency and minimize potential biases. Second, two researchers conducted data analysis according to the agreed-upon criteria. Third, the analysis results underwent five rounds of collaborative review. During this process, each researcher independently evaluated the results, discussed potential interpretative differences, and ultimately reached a consensus on the final analysis. The data collection and analysis utilized TEXTOM as well as UCINET6.0 (Analytic Technologies, Harvard, MA, USA) and NetDraw (Analytic Technologies, Lexington, KY, USA) [31].

Data refinement

Among the 21,216 documents collected through TEXTOM, advertisements and duplicate data were removed, resulting in 8671 cases for analysis. Data preprocessing was conducted in two

the formula proposed by Sun Cheong-nan [36], which is a modified version of Donohue's (1973) formula for distinguishing high-frequency core keywords from low-frequency peripheral keywords based on the word frequency. The formula is as follows:

$$\text{Number of core keywords} = \frac{-1 + \sqrt{1 + 4(\text{Total number of extracted keywords})}}{2}$$

stages. In the first stage, single-syllable words and noninformative terms were removed. In the second stage, similar and synonymous terms were unified to enhance consistency. The preprocessing process was performed using TEXTOM by identifying and refining specific keywords.

Frequency matrix extraction

Using the matrix program provided by TEXTOM, a frequency analysis was conducted to examine overall keyword patterns and temporal trends. Term frequency (TF) and term frequency–inverse document frequency (TF-IDF) analyses were performed. TF-IDF is a widely used metric that reflects the relative importance of a word by accounting for both its frequency and distribution across documents [29]. The top 100 keywords based on TF-IDF values were extracted and visualized using a word cloud, in which keyword size represents relative importance.

Topic modeling analysis

Topic modeling is a method used to identify latent themes in unstructured text by grouping semantically similar words [32]. In this study, the latent Dirichlet allocation model implemented in machine learning for language toolkit (MALLET) [33] was used to explore primary topics related to care robots and to identify keywords with high probabilities of assignment to each topic. The latent Dirichlet allocation model was performed with 100 iterations, $\alpha = 0.5$, and $\beta = 0.01$.

To determine the optimal number of topics, the coherence score method was used. Topics were selected based on the highest coherence score and the semantic interpretability of keywords. In this study, the final model consisting of four topics was selected based on the coherence score (−2.16) and the interpretability of the extracted keywords and the representative texts. While topic modeling is known as an effective method for extracting potential information from literature by minimizing researcher subjectivity, a concern remains about subjective interpretation when labeling topics [34]. To mitigate this potential bias, both keyword composition and representative texts associated with each topic were examined. In addition, the most highly associated representative texts were extracted from the dataset and used to support the labeling of topics, thereby enhancing analytical objectivity [35].

Semantic network analysis

Semantic network analysis is a method for visualizing keywords according to their frequency and relational connections within a network structure. This approach enables the identification of textual meaning and characteristics embedded in large-scale textual data [22]. Through the data refinement process, 9724 keywords were extracted from 8671 documents. Because the total number of extracted keywords was too large to include in the semantic network analysis, it was necessary to select a smaller set of core keywords. To identify these keywords, this study applied

Based on this formula, approximately 100 keywords were selected for semantic network analysis.

The number of clusters was determined using a dendrogram, which represents hierarchical clustering of keywords in a tree-structured graph. This method was used to establish classification criteria and to ensure that all selected keywords were assigned to appropriate clusters.

The selected keywords were converted into a one-mode matrix dataset using TEXTOM and analyzed for degree centrality using UCINET 6.0. Degree centrality indicates how frequently a keyword is connected to other keywords and is calculated as a ratio of the maximum possible connections. This metric was used to identify the most influential keywords within each cluster and to interpret its core semantic structure [37].

The overall network structure was examined using NetDraw, and a convergence of iterated correlations (CONCOR) analysis was performed to identify clusters within the text. The CONCOR analysis identifies keyword clusters by detecting node blocks based on Pearson correlations within the matrix and analyzing interblock relationships. This method facilitates the identification of relationships among similar keywords and the formation of clusters [38].

To integrate the findings from topic modeling and semantic network analysis, an analytic framework based on thematic integration was applied. The mapping of semantic clusters to social value domains was conducted using a systematic approach that considered keyword centrality, thematic similarity, and conceptual alignment with established frameworks of social value in prior literature [10,40]. This process enabled a structured and transparent classification of clusters into broader social value domains, supported by both quantitative indicators (keyword centrality) and qualitative thematic interpretation.

Results

Frequency analysis of care robot–related keywords

Frequency analysis

Between 2021 and 2023, monthly data related to care robots were collected from domestic portal sites and social networking services. The overall data volume showed variability over time, making it difficult to identify a consistent trend ($R^2 = .163$) [39]. Nonetheless, two notable peaks were observed: one in March 2022 and another in December 2023.

The spike in March 2022 coincided with the announcement of the “National Advanced Industry Promotion Strategy” by the Ministry of Trade, Industry, and Energy, which emphasized the development of high-tech industries including robotics. Similarly, the sharp increase in December 2023 followed the government's declaration of the “Advanced Robotics Industry Vision and Strategy,” which positioned robotics as a key future growth engine and

Table 1 Care Robot Keyword Frequency and Inverse Document Frequency.

No.	Word	Frequency	Ratio	Word	TF-IDF
1	Robot	15,919	8.05	Older adult	6113
2	Older adult	10,621	5.37	Companion robot	5818
3	Service	5456	2.76	Business	5140
4	Business	4373	2.21	Service	5095
5	Artificial intelligence	4365	2.21	Artificial intelligence	4975
6	Companion robot	4076	2.06	Care	4799
7	Care	3808	1.93	Technology	4553
8	Technology	3242	1.64	Dementia	4536
9	Support	2864	1.49	Support	4398
10	Living alone	2372	1.20	Living alone	4045
11	Dementia	2119	1.07	Welfare	3732
12	Society	2002	1.01	Society	3557
13	Welfare	1948	0.99	Health	3546
14	Health	1869	0.95	Smart	3462
15	Smart	1715	0.87	Human being	3341
16	Development	1691	0.86	Development	3200
17	Human being	1600	0.81	Friend	2975
18	Friend	1326	0.67	Robot	2918
19	Medical	1218	0.62	Medical	2848
20	Living	1206	0.61	Management	2695
21	Management	1197	0.61	Center	2678
22	Distribution	1130	0.57	Distribution	2608
23	Center	1089	0.55	Living	2608
24	Recipient	1074	0.54	Recipient	2591
25	Enterprise	1027	0.52	Enterprise	2452
26	Disabled person	934	0.47	Disabled person	2403
27	Children	897	0.45	Children	2367
28	Education	888	0.45	Education	2307
29	Prevention	884	0.45	Prevention	2193
30	Necessary	850	0.43	Era	2135
31	Era	847	0.43	Market	2129
32	Future	844	0.43	Future	2123
33	Daily	841	0.43	Safety	2077
34	Promote	840	0.43	Necessary	2075
35	Expansion	832	0.42	Expansion	2074
36	Market	815	0.41	Promote	2072
37	Possible	806	0.41	Daily	2058
38	Safety	802	0.41	Possible	1998
39	Emotion	748	0.38	Emotion	1968
40	House	711	0.36	House	1959
41	Research	673	0.34	Research	1891
42	System	658	0.33	Policy	1825
43	COVID	641	0.32	System	1808
44	Policy	634	0.32	COVID	1788
45	Economy	606	0.31	Economy	1754
46	Role	605	0.31	Innovation	1734
47	Information	601	0.30	Platform	1731
48	Community	591	0.30	Invest	1710
49	News	590	0.30	News	1707
50	Innovation	588	0.30	Information	1689
51	Platform	585	0.30	Long-term care	1686
52	Region	579	0.29	Community	1682
53	Depression	565	0.29	Role	1680
54	Customized	551	0.28	Family	1655
55	Invest	548	0.28	Region	1655
56	Family	546	0.28	Reassurance	1652
57	Long-term care	542	0.27	Hospital	1646
58	Hospital	541	0.27	Depression	1631
59	Plan	536	0.27	Socially disadvantaged	1617
60	Reassurance	529	0.27	Customized	1589
61	Conversation	524	0.27	Plan	1580
62	Socially disadvantaged	518	0.26	Conversation	1553
63	Emergency situation	510	0.26	Government	1537
64	Government	507	0.26	Emergency situation	1506
65	Vulnerable groups	488	0.25	Product	1505
66	Product	485	0.25	Vulnerable groups	1496
67	Home	481	0.24	Country	1479
68	Citizen	469	0.24	Citizen	1463
69	Country	461	0.23	Lonely death	1456
70	Aging	454	0.23	Home	1447
71	Data	440	0.22	Rehabilitation	1437
72	Lonely death	438	0.22	Aging	1415
73	Life	430	0.22	City	1400
74	Program	429	0.22	Data	1392

Table 1 (continued)

No.	Word	Frequency	Ratio	Word	TF-IDF
75	Rehabilitation	423	0.21	Program	1391
76	Trend	421	0.21	Trend	1381
77	City	416	0.21	Labor	1381
78	Labor	404	0.20	Experience	1378
79	Manpower	398	0.20	Life	1325
80	Advancement	398	0.20	Institution	1307
81	Institution	396	0.20	Work	1293
82	Work	394	0.20	Device	1290
83	Device	390	0.20	Advancement	1280
84	Experience	387	0.20	Manpower	1267
85	Individual	385	0.20	Challenge	1252
86	Assistance	378	0.19	Individual	1250
87	Environment	378	0.19	Nursing	1245
88	Challenge	375	0.19	Friendly	1244
89	Growth	374	0.19	Environment	1233
90	Nursing	357	0.19	Assistance	1232
91	Help	353	0.18	Growth	1222
92	Wearable	353	0.18	Agreement	1218
93	Exhibition	346	0.18	Wearable	1189
94	Internet of things	346	0.18	Exhibition	1188
95	Friendly	343	0.17	Visit	1180
96	Demand	342	0.17	Phone call	1167
97	Agreement	335	0.17	Internet of things	1167
98	Phone call	334	0.17	Help	1160
99	Medication	331	0.17	Demand	1156
100	Visit	330	0.17	Smart speaker	1142

COVID = Coronavirus Disease; TF-IDF = term frequency–inverse document frequency.

substantially expanded the industry's budget. These policy events likely triggered increased public and media interest in care robotics during those periods.

Keyword frequency matrix extraction

A total of 21,216 documents were collected in the study, containing 29,614 keywords. After preprocessing, the number of unique keywords was reduced to 9724. The TF and TF-IDF values are presented in Table 1.

The most frequently occurring keywords (TF) were “robot,” “older adult,” “service,” “business,” and “artificial intelligence.” In contrast, the TF-IDF rankings showed slight differences, with “older adult,” “companion robot,” “business,” “service,” and “artificial intelligence” ranking the highest. These differences indicate that some keywords appeared frequently across the dataset, whereas others were identified as more important in specific contexts based on TF-IDF values. Moreover, the extracted keywords indicate that discussions surrounding care robots encompassed not only technological aspects, such as companion robots and artificial intelligence, but also broader contextual aspects, including business models, government support, and older adults living alone.

The word cloud visualization of the top 100 TF-IDF keywords is shown in Figure 1. The most prominent terms—such as “companion robot,” “older adult,” “business,” and “artificial intelligence”—were visually emphasized in the word cloud, corresponding to high TF-IDF values. These findings provide a foundational overview of the key terms that inform the subsequent structural and contextual analyses.

Topic modeling results

In this study, four topics were identified based on coherence score evaluation, with each topic consisting of 20 keywords. The selected model showed distinct visual separation between topics and limited overlap in the intertopic distance map and was therefore considered appropriate based on coherence scores and



Figure 1. Word cloud visualization of top TF-IDF keywords related to care robots. TF-IDF = term frequency–inverse document frequency.

Topic	Topic name	Core keywords	Ratio (%)
1	Companion robots supporting care to bridge the care gap	Companion robot, living alone, dementia, friend, recipient, health, distribution, life, center, management, emotion, prevention	34.3
2	Care robots leading new economic trends	Trends, economy, future, investment, market, innovation, enterprise, role, possible	25.7
3	Care robots supporting human care across various sectors	Human, welfare, children, education, era, disabled person, thought, individual, substitute, humanoid, emotion, relationship	15.3
4	Government-led expansion of social care through care robots	Medical, development, citizen, care, promote, country, expansion, government, nursing	24.7
-	(Common keyword)	Older adult, robot, service, business, society, artificial intelligence, care, technology	-

AI-powered conversation abilities, serving as a talking companion for older adults. Mapodong-i was specifically designed to assist older adults struggling with chronic depression and cognitive impairments (Original Data ID: 171).

Care robot support for high-risk dementia older adults (Dongdaemun district initiative). Dongdaemun district has distributed care robots, each named “Aria,” to high-risk older adults with dementia. A total of 156 IoT-based AI care speakers were deployed to households of older adults living alone or those with dementia. Aria is equipped with various voice-recognition functions, including cognitive training, medication management, information provision, and emergency assistance requests (Original Data ID: 334).

Topic 2: Care robots leading new economic trends

The second topic consisted primarily of the keywords “trend,” “economy,” “future,” “invest,” “market,” “innovation,” “enterprise,” “role,” and “potential.” Based on these keywords, this topic was labeled “Care Robots Leading New Economic Trends.”

The findings indicate that care robots are associated with economic and industrial developments, including market expansion, technological innovation, and investment activities. The keywords reflect discussions related to business strategies, enterprise roles, and future market potential. These patterns indicate that care robots are discussed not only as assistive technologies but also in relation to economic growth and innovation, particularly in the context of aging societies and changing care demands.

Distribution of companion robots for the older adults living alone (Mapo district). As a proactive measure to address the social isolation and depression of older adults in the post-COVID era, the government plans to integrate personalized care services with companion robots. The most notable feature of “Mapodong-i,” the companion robot, is its

To illustrate the relevance of topic 2, the following representative texts were extracted from the dataset:

ADIEU 2020: The dawn of the service robot era. As part of the third Intelligent Robot Master Plan, the government has promoted four key service robot categories: care robots, wearable robots, medical robots, and logistics robots. While it may be premature to claim that South Korea has fully moved away from a manufacturing-centric robot industry, it is clear that the service robot market—long anticipated by the domestic robotics sector—is now beginning to flourish (Original Data ID: 34).

Trillion KRW investment in robots for patient care and infectious disease management. The South Korean government has announced an investment of 2.2 trillion KRW this year to develop robotic technologies for managing infectious disease outbreaks such as COVID-19. As part of this initiative, over 1700 care robots will be deployed nationwide (Original Data ID: 1289).

Topic 3: Care robots supporting human care across various sectors

The third topic consisted primarily of the keywords “human,” “welfare,” “children,” “education,” “era,” “disabled person,” “thought,” “individual,” “substitute,” “humanoid,” “emotion,” and “relationship.” Based on these keywords, this topic was labeled “Care Robots Supporting Human Care Across Various Sectors.”

The findings indicate that care robots are associated with human care across multiple sectors, including childcare, education, and disability welfare. The keywords reflect discussions related to social welfare systems, emotional support, and individualized care. In particular, care robots are discussed in relation to supporting children’s development and enhancing autonomy among people with disabilities. These patterns suggest that care robots are positioned within broader welfare contexts that emphasize human-centered care and social support systems.

To illustrate the relevance of topic 3, the following representative texts were extracted from the dataset:

Strengthening the welfare system with artificial intelligence technology to prevent child abuse. AI-based services are being integrated into the social welfare system, including older adult care. Following the Jeong-in child abuse case, public opinion has increasingly emphasized the need to utilize AI technology to improve child welfare services. Experts advocate for institutional innovation, stricter oversight, and the development of AI systems to monitor social welfare blind spots. There is a growing consensus that AI-powered programs should be expanded to prevent cases of child abuse and solitary deaths caused by workforce shortages (Original Data ID: 26).

Smart care space assisting the daily lives of people with disabilities using robots. Selected as the “Korean New Deal Place of the Month,” the Smart Care Space at the National Rehabilitation Center is a site that conducts empirical research on four types of care robots within an environment designed like a typical home. Care robots and sensors are discreetly installed so that older adults or people with disabilities who have difficulty moving independently can lead a daily life without inconvenience with the assistance of care robots (Original Data ID: 965).

Topic 4: Government-led expansion of social care through care robots

The fourth topic consisted primarily of the keywords “medical,” “development,” “citizen,” “care,” “promote,” “country,” “expansion,” “government,” and “nursing.” Based on these keywords, this

topic was labeled “Government-Led Expansion of Social Care through Care Robots.”

The findings indicate that care robots are associated with government-led initiatives in the expansion of medical and care-giving services. The keywords reflect discussions related to policy development, public sector involvement, and the integration of care robots into healthcare and long-term care systems. In the context of aging societies, care robots are increasingly discussed in relation to the expansion of social care services and the management of growing care demands.

To illustrate the relevance of topic 4, representative texts were extracted from the dataset:

Government focuses on developing digital care technologies to address unmet needs. The government has announced plans to expand research support for older adult care. Additionally, it has emphasized the development of a government-led big data initiative to improve patient information accessibility by proposing rational solutions for advancing digital care technologies (Original Data ID: 5284).

Gwangyang welfare caregiving project implements excretion assistance robots. The Excretion Assistance Robot Project was selected as a government-funded initiative in 2018. The project aims to improve hygiene management for older adults who have difficulty managing their own toileting needs while also reducing the burden on care-giving staff. These robots have been distributed and operated in local nursing facilities and home care settings (Original Data ID: 1746).

Semantic network analysis results

In this study, 9724 keywords were extracted through semantic network analysis, of which the top 100 were selected. These 100 keywords (nodes) exhibited 9880 ties (connections), resulting in a network density of 1.00 and a standard deviation of 0.05. The selected keywords were organized into eight clusters using CONCOR analysis, with the naming and interpretation of each cluster based on the centrality of the keywords (Figure 2).

The first cluster consisted of keywords such as “older adult,” “artificial intelligence,” “care,” “support,” and “living alone,” reflecting a close association between community-based care and technological support. Notably, “older adult” exhibited the highest degree of centrality, indicating that it occupies a central position within the network structure of this cluster. This pattern suggests that discussions in this cluster are primarily focused on older adult care in the context of aging societies, particularly regarding individuals living alone and the use of smart care technologies. These findings reflect an emphasis on older adults as a key population in discussions of care technology and care provision. Accordingly, this cluster was labeled “Health care support for vulnerable populations using smart care technology.”

The second cluster consisted of keywords such as “companion robot,” “friend,” “prevention,” “depression,” and “medication,” reflecting discussions related to emotional interaction and mental health support. Notably, “companion robot” exhibited the highest degree of centrality, suggesting that discussions in this cluster are focused on companionship, emotional support, depression prevention, and the mitigation of social isolation. These findings reflect the role of care robots in addressing emotional and psychological needs in care contexts. Accordingly, this cluster was labeled “Companion robots for emotional bonds and mental health enhancement.”

The third cluster consisted of keywords such as “dementia,” “center,” “recipient,” “reassurance,” and “program,” reflecting discussions related to care services for individuals with dementia.

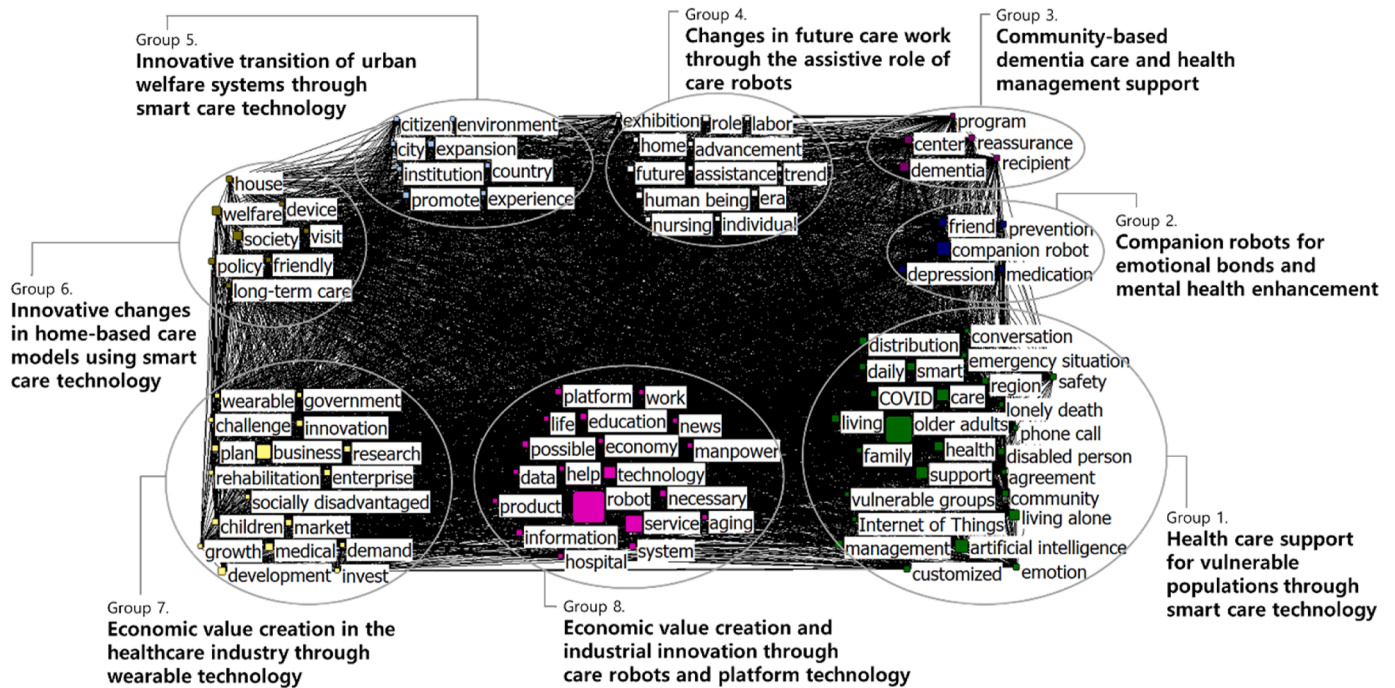


Figure 2. CONCOR analysis results of care robot network.

Notably, “dementia” exhibited the highest degree of centrality, suggesting that discussions are centered on structured care programs and community-based service provision for individuals with cognitive impairment. These findings reflect the importance of dementia care within the broader context of care services. Accordingly, this cluster was labeled “Community-based dementia care and health management support.”

The fourth cluster consisted of keywords such as “human,” “era,” “future,” “role,” and “home,” reflecting discussions on the role of humans in care and its relationship with technological advancement. Notably, “human” exhibited the highest degree of centrality, suggesting that discussions are focused on how human care roles are situated within evolving technological environments. These findings reflect ongoing considerations regarding the interaction between human caregivers and care technologies. Accordingly, this cluster was labeled “Changes in future care work through the assistive role of care robots.”

The fifth cluster consisted of keywords such as “promote,” “expansion,” “citizen,” “country,” and “city.” These keywords were intricately associated with topics concerning the expansion of urban care welfare, grounded in smart technologies and the orientation of related policy initiatives. Notably, “promotion” and “expansion” exhibited the highest degree of connectivity, indicating that discussions within this cluster concentrated on policy trends aimed at broadening and fortifying the smart care welfare system at both the national and community levels. This implies that technology-driven innovations in care enable a structural transformation of urban welfare. Consequently, this cluster was labeled “Innovative transition of urban welfare systems through smart care technology.”

The sixth cluster consisted of keywords such as “welfare,” “society,” “house,” “policy,” “long-term care,” and “visit,” which were intricately linked to topics concerning the expansion of home-based care services and the evolution of welfare policies through the utilization of smart technologies. Notably, the term “welfare” exhibited the highest degree of centrality, suggesting that the discussions are focused on the expansion of home-based

care and the development of welfare systems. These findings reflect the increasing importance of community-based and home-centered care services. Accordingly, this cluster was labeled “Innovative changes in home-based care models using smart care technology.”

The seventh cluster consisted of keywords such as “business,” “development,” “medical,” “rehabilitation,” and “wearable,” reflecting discussions related to the application and industrial expansion of wearable technology in the domains of care and rehabilitation. Notably, “business” exhibited the highest degree of centrality, suggesting that discussions are centered on economic activities such as technological development, investment, and market expansion. These findings reflect discussions related to the integration of wearable technology into industrial and economic domains within care and rehabilitation contexts. Accordingly, this cluster was labeled “Economic value creation in the healthcare industry through wearable technology.”

The eighth cluster consisted of keywords such as “robot,” “service,” “technology,” “education,” “necessary,” and “platform,” reflecting discussions related to service development and technological integration. Notably, “robot” exhibited the highest degree of centrality, suggesting that discussions are focused on the role of care robots in service provision and platform-based technological systems. These findings reflect the expansion of care robot applications within service and technology ecosystems. Accordingly, this cluster was labeled “Economic value creation and industrial innovation through care robots and platform technology.”

Exploration of social values

Based on the analytic framework described in the Methods section, semantic clusters were systematically mapped onto social value domains by integrating the results of topic modeling and semantic network analysis, considering keyword centrality and thematic similarity. Clusters were assigned to domains based on

Social Value	Health Value	Economic Value	Labor Value	Innovative Value
Main Topic	Companion robots supporting care to bridge the care gap	Care robots leading new economic trends	Care robots supporting human care across various sectors	Government-led expansion of social care through care robots
Subtopic	- Health care support for vulnerable populations using smart care technology - Companion robots for emotional bonds and mental health enhancement - Community-based dementia care and health management support	- Economic value creation in the healthcare industry through wearable technology - Economic value creation and industrial innovation through care robots and platform technology	Changes in future care work through the assistive role of care robots	- Innovative transition of urban welfare systems through smart care technology - Innovative changes in home-based care models using smart care technology
Keyword	older adult, living alone, companion robot, life, daily life, depression, emotion, management, vulnerable groups, lonely death, Internet of Things, COVID	market, economy, invest, enterprise, growth, service, technology, medical, platform, wearable	human, welfare, substitute, era, role, labor, nursing, assistance, humanoid, emotion, relationship	country, city, development, promote, development, institution, center, citizen, environment

Figure 3. Results of the analysis on the social value of care robots.

the dominant centrality patterns of keywords representing their core semantic structure. Four key social value domains associated with care robots were identified (Figure 3), informed by established frameworks of social value in prior literature [40].

The first domain is health value. This domain was derived by grouping the semantic network clusters “Health care support for vulnerable populations using smart care technology,” “Companion robots for emotional bonds and mental health support,” and “Community-based dementia care and health management support” under the topic modeling theme “Companion robots supporting care to bridge the care gap.” These clusters reflect discussions related to supporting vulnerable populations, including older adults living alone and individuals with dementia, as well as emotional support and health management functions. This domain is consistent with the concept of public health, which emphasizes the protection and enhancement of health and well-being.

The second domain is economic value. This domain was derived by grouping the semantic network clusters “Economic value creation in the healthcare industry through wearable technology” and “Economic value creation and industrial innovation through care robots and platform technology” under the topic modeling theme “Care robots leading new economic trends.” These clusters reflect discussions related to technological development, market expansion, and investment activities associated with care robots. This domain corresponds to economic value in terms of production, distribution, and industry development.

The third domain is labor value. This domain was derived by grouping the semantic network cluster “Changes in future care work through the assistive role of care robots” under the topic modeling theme “Care robots supporting human care across various sectors.” This cluster reflects discussions related to the role of care robots in supporting or complementing human labor in caregiving contexts, particularly in relation to workforce demands and caregiving tasks.

The fourth domain is innovative value. This domain was derived by grouping the semantic network clusters “Innovative transition of urban welfare systems through smart care technology” and “Innovative changes in home-based care models using smart care

technology” under the topic modeling theme “Government-led expansion of social care through care robots.” These clusters reflect discussions related to policy-driven expansion, technological integration, and the development of new care environments. This domain aligns with innovation-related value in terms of system transformation and service development.

Discussion

This study aimed to explore how public discourse surrounding care robots is represented through the analysis of unstructured data. Based on this analysis, the study investigated the social values that care robots generate. The findings confirmed that care robots generate four key social values: health, economic, labor, and innovative value. This discussion is structured around these four aspects.

The first identified social value of care robots is health value, which encompasses improvements in quality of life, health, welfare, and social integration [41]. These values highlight the potential of care robots to support daily activities and provide emotional stability, thereby promoting autonomy and dignity. In addition, by ensuring continuity of care, care robots contribute to strengthening community cohesion. Notably, the predominant use of care robots for vulnerable groups, such as the elderly, in this study has significant implications from the perspective of person-centered nursing theory [42]. This theory regards care recipients as individuals with unique values and beliefs, emphasizing the importance of respecting their human rights and autonomy to help them lead a dignified life [43]. However, it has been pointed out that in actual clinical settings, severe staff shortages and time pressures lead to a lack of communication between nurses and patients, restricting patient autonomy and positive care experiences within an efficiency-driven care system [44,45].

In this context, care robots are gaining attention as a practical approach to bridge the gap in human-centered care. Christoforou et al. [7] noted that care robots restructure the care process by taking over repetitive tasks such as item delivery, patient transfer assistance, and vital sign monitoring. This allows nurses to devote more time to direct care, such as assessing subtle changes in

patients' conditions and providing emotional support. Vande-meulebroucke et al. [46] found that patients receiving robotic support experience less shame and helplessness, which are often associated with dependence on caregivers for sensitive daily activities such as excretion or mobility. Instead, patients reported a more positive and proactive care experience, with greater control over their daily lives. Furthermore, Pu et al. [47] reported that interaction with care robots significantly reduces anxiety and isolation in older adult patients, providing a sense of stability. Consequently, care robots are evaluated as tools that establish a practical foundation for nurses to fully utilize their human-centered care competencies while simultaneously ensuring continuity of care and dignity for patients.

The second social value is economic value, which can be measured by the benefits gained through the reduction of care labor and the promotion of the workforce's health [40]. In the nursing context, economic value can be understood as the long-term reduction in healthcare costs achieved through optimized nursing workflows and preventive care processes. By taking over repetitive and simple tasks, care robots enable the efficient allocation of nursing staff, leading to a decrease in turnover rates, which consequently reduces the substantial recruitment and training costs for hospitals [11]. In particular, robots pre-emptively prevent patient safety incidents by detecting, in real time, subtle postural changes in high-risk groups for falls and pressure ulcers, or the risk of medication errors [48]. Such preventive measures reduce social costs by avoiding prolonged hospital stays and additional treatment expenses caused by complications [49]. Furthermore, telecare and mobility assistance robots play an instrumental role in providing services to older adults in areas with limited healthcare access. This helps bridge regional and socioeconomic disparities in care [5] and demonstrates their potential as a resource allocation strategy that effectively distributes limited healthcare resources to critically ill patients who need them most.

The third identified social value of care robots is the labor value. As care robots take over essential caregiving tasks, they reduce the burden on caregivers [40] and improve working conditions [50]. Such improvements in the work environment foster a setting that enables nurses to concentrate on core nursing practices, including clinical decision-making that requires professional expertise and complex symptom management [51]. The systematic advancement of human-centered nursing practice has been identified as a crucial element in improving nurses' job satisfaction and team effectiveness while also reducing turnover rates [42,52], and it facilitates transformations in organizational nursing culture [53]. In this regard, the labor value of care robots is significant not only for augmenting work efficiency but also for fostering a cultural foundation where nurses are respected and can develop professionally. In essence, care robots should be designed as instruments that create environments enabling nurses to concentrate on human care and exercise autonomous and ethical judgment. However, the introduction and widespread use of care robots have raised various ethical concerns. Robot-assisted care may engender new care inequalities due to disparities in technological accessibility [54], and there may be ambiguity regarding accountability for errors or decision-making during the care process [55]. Furthermore, if care is delivered without human contact and relationship building, concerns may arise regarding the depersonalization of care [56]. However, incorporating technology into care does not inherently diminish humanity. According to Locsin's [9] theory of caring as a technological competency, technology is not a substitute for humans but a means of understanding individuals holistically and enhancing human dignity. That is, the more adept nurses are at utilizing technology, the more time and energy they can devote to

human-centered caring relationships [9,57]. Therefore, care robots should not be perceived merely as technology replacing nurses' work; they should be strategically integrated as a means to support nurses' expertise and ethical judgment, thereby implementing a human-centered nursing culture sustainably.

Finally, the social value of care robots is innovative value. Care robots drive technological advancements and contribute to the creation of new care environments, thereby addressing emerging social challenges [58] and promoting sustainable innovation within organizations [40]. Such technological advancements are pivotal in mitigating structural challenges, including population aging, caregiving personnel shortages, and care gaps, thereby transforming care systems into more resilient and sustainable models [59].

Sensors and artificial intelligence technology embedded in care robots act as a data hub that continuously collects patients' vital signs, medication history, sleep patterns, and activity levels [60]. This shifts nurses' patient assessments from subjective observation to an objective, continuous data-driven approach. The collected data are integrated with electronic medical records in real-time to support accurate and efficient nursing documentation. Furthermore, it drives digital innovation in practical workflows by predicting subtle changes in a patient's condition, thereby enabling systematic handovers among healthcare providers, as well as timely decision-making and reporting [61]. Moreover, it accelerates the transition from hospital-centric care to community-based care and enables the expansion of new forms of nursing services, such as visiting nursing and telenursing mediated by robotic technology.

Such infrastructure innovation ensures patient autonomy and independence. Care robots act as a core element of "aging in place," helping patients live while maintaining autonomy and dignity in familiar environments without being admitted to a facility [62]. The technology-driven care infrastructure, which breaks down the spatiotemporal constraints of care, resolves care gaps caused by geographical and physical limitations. It contributes to achieving the public health goal of health equity by establishing a structure where all individuals have equal access to care and health services [63]. Overall, care robots hold potential as an innovative tool that comprehensively transforms the space, method, and accessibility of care.

While this study focused on data from 2021 to 2023, it did not incorporate data from the early phase of the COVID-19 pandemic in 2020. This limitation may have restricted a more comprehensive analysis of the initial surge in demand for care robots and related societal discourse. Although the dataset provided meaningful insights into social discourse during the study period, more recent changes in public perception, policy direction, and emerging technological developments related to care robots may not have been fully reflected. Therefore, the findings should be interpreted within the temporal scope of the data analyzed. The data sources were also limited to selected portal sites and social media platforms suitable for text-based analysis. Platforms centered on visual content, such as Instagram, and microblogging platforms, such as Twitter (currently X), were excluded due to their data characteristics. Accordingly, the findings may not fully reflect the broader range of online discourse across diverse digital platforms, which may affect the representativeness and generalizability of the results. Despite these limitations, the integration of topic modeling and semantic network analysis provided a comprehensive perspective on the social value and practical implications of care robots. Although the four overarching domains identified in this study were broadly aligned with existing frameworks, the findings further elucidate more specific and contextually grounded dimensions within each domain. In particular, this study

highlights how care robots are associated with dignity in sensitive care activities, optimization of nursing workflows, and support for aging in place, which have not been explicitly detailed in prior frameworks. Rather than proposing entirely new overarching domains, this study contributes by empirically demonstrating how these domains are manifested, specified, and refined within contemporary public discourse. In addition, because the data primarily reflected institutional perspectives, they may not have sufficiently captured the lived experiences of actual users, such as patients and caregivers. Future research should incorporate more recent data, a broader range of digital platforms, and user-centered approaches, including user-generated content and qualitative methods, to better capture evolving societal attitudes and the real-world implementation of care robots.

Conclusion

This study aimed to explore the public discourse surrounding care robots and identify key themes related to their social value. Based on these findings, the study examined the social value of care robots and suggested directions for their application.

The analysis identified four primary social values of care robots: health, economic, labor, and innovative value. These findings demonstrate that care robots transcend their fundamental role of providing care owing to their potential to address social challenges, create new welfare and economic opportunities, and drive innovation in the care environment. Additionally, the study found that current discussions on care robots are predominantly shaped by care robot providers, while interest and engagement from potential users, such as the general public, remain relatively low. This finding highlights the need for greater efforts to raise awareness about the social value of care robots and to enhance public acceptance and engagement of them.

To facilitate the widespread adoption of care robots, continuous research should be conducted to provide empirical evidence of their positive impact and to establish a clear framework for communicating their benefits. Moreover, it is essential to develop strategic public awareness campaigns and educational programs to foster understanding and acceptance among potential users. For care robots to be effectively integrated into society and contribute to social inclusion and a sustainable welfare system, collaboration and dialog among various stakeholders—including governments, industry leaders, caregivers, and users—are essential.

Author contributions

1. Yong Soon Shin: Conceptualization; methodology; writing—review investigation and editing.
2. Hye-Young Jang: Conceptualization; methodology; formal analysis; writing—review and editing.
3. Jung-A Kim: Methodology; formal analysis; writing—review and editing.
4. Min-Soo Kang: Methodology; formal analysis; writing—review and editing.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflict of interest

The authors declare that there are no competing interests.

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There are none to declare.

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