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Exploring Research Topics and Trends in Nursing-related Communication in Intensive Care Units Using Social Network Analysis

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This study used social network analysis to identify the main research topics and trends in nursing-related communication in intensive care units. Keywords from January 1967 to June 2016 were extracted from PubMed using Medical Subject Headings terms. Social network analysis was performed using Gephi software. Research publications and newly emerging topics in nursing-related communication in intensive care units were classified into five chronological phases. After the weighting was adjusted, the top five keyword searches were "conflict," "length of stay," "nursing continuing education," "family," and "nurses." During the most recent phase, research topics included "critical care nursing," "patient handoff," and "quality improvement." The keywords of the top three groups among the 10 groups identified were related to "neonatal nursing and practice guideline," "infant or pediatric and terminal care," and "family, aged, and nurse-patient relations," respectively. This study can promote a systematic understanding of communication in intensive care units by identifying topic networks. Future studies are needed to conduct large prospective cohort studies and randomized controlled trials to verify the effects of patient-centered communication in intensive care units on patient outcomes, such as length of hospital stay and mortality.

KEY WORDS: Communication, Intensive care units, Research topics, Social network analysis, Trends

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Effective communication has a greater impact on quality of care in ICUs than it does in other healthcare settings because of the demand for accurate and timely processing of work. Effective communication also helps healthcare providers, patients, and family members cope with emergency situations.[1,2]

Communication has been studied in a wide variety of healthcare settings.[3,4] Most studies regarding communication were conducted to investigate problems in communication and to suggest solutions, such as good communication skills and effective interview techniques.[3–6] In contrast, studies regarding communication in ICUs have been performed recently to identify communication barriers,[7,8] develop educational programs for effective communication,[9,10] and identify the effects of communication in ICUs on patient outcomes.[11,12] However, there have been relatively limited studies on communication in ICUs, despite that effective communication for patients, their family caregivers, and healthcare professionals is essential to improve quality of patient care and patient health outcomes.

Understanding the concept of research by clarifying research trends is valuable and helpful not only for future research but also for the development of a systematic body of knowledge.[9,13] In particular, reviewing and analyzing previous studies of meaningful evidence of communication in ICUs can contribute to patient-centered care for ICU patients. It can also improve the skills of nurses, which will not only benefit patients and their families but also help to develop professional nursing practice and provide an ongoing clinical challenge in various healthcare settings.

Information on the topics researchers find most interesting is important in order to understand the past and prepare for the future; therefore, it is relevant to survey the published literature.[14] Social network analysis (SNA) uses graphs to illustrate entities in a social structure as nodes (people, organizations, genes) and the relationships between those entities as edges (connections, interactions).[15] For the purposes of this study, SNA-based text mining has a number of strengths and advantages. It can reveal the meaning of various entities through the visualization of relationships between individual entities, detect microscopic topic networks among specific

research topics, and easily identify overlooked concepts in existing studies.[16] These techniques can make a valuable contribution to the mapping and analysis of information sharing structures.[17]

Unfortunately, previous analytical methods not only demanded significant labor but were also faced with practical limitations due to time, effort, and accuracy requirements. However, text mining using a computer program designed for SNA is particularly useful for analyzing the extensive text materials and micro-topics of Big Data, and is therefore widely used in various academic fields, including nursing.[18,19] Social network analysis–based text mining identifies the range of analysis as titles, keywords provided by authors, abstracts, and main articles. It represents the impact of a word in the form of a network statistics index that analyzes the rate and trend of co-occurrence, or the rate at which two words appear in an adjacent context. A meaningful relational structure can be derived from such findings, since one can identify the relationships between important terms with particular connections. Social network analysis–based text mining also provides a sociogram in which each word and its co-occurrence are represented by a node and links, respectively, thus enabling the researcher to apprehend the relationships between words in a comprehensive and insightful way.[19]

Nurses frequently work as part of multidisciplinary teams, and communication between patients, family members, caregivers, and team members is critical in the delivery of quality care in ICUs. Our study using SNA facilitates the identification of research topics and trends in ICU communication. The co-occurrence pattern analysis of terms indicates the presence of networks that form a fairly clear map of ICU communication research.

We hope that a network perspective can generate better uptake and utilization of knowledge concerning communication in ICUs. Using SNA, this study therefore aimed to investigate the frequency, relatedness, and connectivity of communication as nodes and connections (edges) of research topics and overall research trends in nursing-related ICU communication.

METHODS

Data Collection and Preparation

We searched for articles in PubMed using Medical Subject Headings (MeSH) terms to identify peer-reviewed studies in English published between January 1967 and June 2016. Our query included terms related to "intensive care unit" or "critical care"; "communication," "conversation," or dialogue"; and "nursing" or "nurses." The frequency matrix size was identified as 1580 × 48 using the annual frequency of MeSH terms.

The weight of MeSH terms was calculated by applying the term frequency used in search information and the document frequency formula.[17] The more centralized the actively used keywords in the network at the time of retrieval, the higher the degree of relatedness.[20] The equation hereinafter represents the relationship between MeSH terms S and T.

$$\text{Relatedness}(S, T) = \frac{\sum_y \min(S_y, T_y)}{\sum_y \max(S_y, T_y)}$$

Data Analysis and Interpretation

The analysis of collected data was divided into a preprocessing stage, a network analysis stage, and a visualization stage. The procedure was as follows: (1) extraction of keywords, (2) appearance frequency and weight calculation of keywords, and (3) creation of a similarity network between keywords. For visualization and exploration, we used Gephi software (Gephi Consortium, Compiegne, France).

As open-source software, Gephi has some advantages compared to other network analysis software.[21] To analyze the topics in ICU communication research, we used the well-established co-word analysis protocol. This protocol assumes that two words (terms) are more closely related than two other words if they co-occur more frequently in a given text corpus. It can reveal the topical landscape of a given field.[22] We assumed that there was a higher correlation between the two keywords if they were used many times, as compared to cases in which they were not.

The centrality describes the extent to which a node is located centrally in the entire network. There are various kinds of indicators that describe centrality, for example, degree centrality, closeness centrality, and betweenness centrality. The centrality of the degree of relatedness is between 0 and 1, with the highest centrality being 1 (100%) and the lowest centrality being 0 (0%). Network centralization refers to the level of the entire network and focuses on several central nodes.[20] Use of the centrality score enabled the extraction of the main research topics based on the information shared between nodes that composed the network.[23]

For the correlation between words, the frequency value of each word's annual appearance was used. The calculation method used in this study is a weighted Jaccard similarity based on the appearance frequency of keywords.[24] According to the Jaccard similarity, if two words are used together with high frequency in multiple years, they return a high similarity value. The frequency matrix and weighted Jaccard similarity yielded values for year-to-year similarity, and grouped research related to the keywords into five phases based on periods.

The keyword clustering was calculated using the Markov Cluster Algorithm,[25] which is widely applied in the computer science field, after constructing a graph that equated keywords with nodes, and the similarity between keywords with the weight of the edges between nodes. The Markov

Cluster Algorithm is a simple algorithm used with sequence data clusters that can be expressed as a weighted graph. It is understood that keywords with a high frequency of simultaneous appearance are used in the same context and have a higher correlation than other words in the same year; that is to say, they return a high similarity value.

Next, a network analysis was performed for all data and for each of the categories. The size of each node was determined using the node's authority score, obtained using a Hypertext-Induced Topic Selection algorithm in Gephi.

RESULTS

Term Frequency and Weight

Before analyzing the network, we identified the most frequently searched keywords among the top 30 keywords related to ICU communication in this study (Table 1). From 1967 to 2016, a total of 1580 keywords related to ICU communication were used for searches. The topic "humans" (1094 cases) was the most frequently searched, followed by "female" (458 cases). "Critical care" (428 cases), "male" (421 cases), and "communication" (378 cases) were among the other ICU communication keywords. After weighting the keywords, the highest ranked keywords in the top 30 were "conflict" (0.453), "length of stay" (0.444), "nursing continuing education" (0.431), and "family" (0.424).

Category Setting Through an Analysis of Keyword Similarity

The degree of similarity was calculated, and the strength of relatedness was displayed by giving a weight to the qualitative aspects of each node or to its relative strength. Jaccard similarity was used as a representative index,[24] and each keyword was listed by year, divided in 3-year sections over approximately 48 years, from 1967 to 2016. To define setting the phase for trend analysis, the cutoff points at which the graph started to increase after decreasing the similarity indicated a significant increase in the change of a keyword. The first phase ranged from 1967 to 1982, the second from 1983 to 1988, the third from 1989 to 2004, the fourth from 2005 to 2008, and the fifth from 2009 to 2016 (Figure 1).

Table 1. ICU Communication Term Frequency and Weight

No	Keywords	Frequency	No	Keywords	Weight
1	Humans	1094	1	Conflict	0.453
2	Female	458	2	Length of stay	0.444
3	Critical care	428	3	Nursing continuing education	0.431
4	Male	421	4	Family	0.424
5	Communication	378	5	Nurses	0.416
6	Intensive care units	377	6	Organizational culture	0.415
7	Adult	373	7	Risk factors	0.412
8	Nursing staff, hospital	333	8	Communication barriers	0.412
9	Middle aged	278	9	Withholding treatment	0.411
10	Attitude of health personnel	249	10	Clinical competence	0.407
11	Surveys and questionnaires	225	11	Practice guidelines as topic	0.406
12	Aged	162	12	Nursing care	0.406
13	Infant, newborn	162	13	Decision making	0.405
14	Professional-family relations	160	14	Continuity of patient care	0.403
15	Nursing methodology research	144	15	Neonatal nursing	0.402
16	Nurse's role	134	16	Prospective studies	0.402
17	Family	119	17	Reproducibility of results	0.402
18	Intensive care units, neonatal	119	18	Job satisfaction	0.400
19	Nurse-patient relations	115	19	Interviews as topic	0.396
20	Qualitative research	114	20	Nurse-patient relations	0.394
21	Interprofessional relations	113	21	Patient satisfaction	0.392
22	Patient care team	112	22	Models, nursing	0.392
23	Decision making	94	23	Organizational policy	0.391
24	Clinical competence	90	24	Intensive care, neonatal	0.390
25	Social support	90	25	Terminal care	0.389
26	Child	87	26	Quality of health care	0.388
27	Critical illness	87	27	Infant	0.386
28	Nursing assessment	80	28	Focus groups	0.385
29	Terminal care	79	29	Visitors to patients	0.382
30	Cooperative behavior	77	30	Intensive care units, neonatal	0.381

Trends in Research Topics by Publication Year

Table 2 summarizes the new research topics emerging in ICU communication, according to the MeSH terms. From 1967 to 1982 (phase 1), there were some research topics within 10 times such as "human," "intensive care unit," and "communication." From 1983 to 1988 (phase 2), new topics included "surveys and questionnaires"; "middle aged"; "intensive care units, neonatal"; "aged"; "nursing assessment"; and "family." From 1989 to 2004 (phase 3), terms included "nursing methodology research," "health knowledge," "attitude practice," "nurse role," "social support," "communication barriers," and "cooperative behavior." From 2005 to 2008 (phase 4), they included "facial expression" and "medical errors." From 2009 to 2016 (phase 5), they included "young adult," "critical care nursing," "quality improvement," "checklist," "patient handoff," "patient safety," "tertiary-care center," and "evidence-based practice."

Clustering by Identifying Network Structure

To visualize network structure in this study, 10 groups of keywords were used. Figure 2 shows the visualization of networks resulting from keyword extraction. For each of the groups, the following keywords demonstrated high relatedness and high weight (see Figure, Supplemental Digital Content 1, http://links. lww.com/CIN/A46, illustrating topic clustering in ICU communication).

In group 1 (see Figure, Supplemental Digital Content 2, http://links. lww.com/CIN/A47, illustrating group 1 of ICU communication topics), the main research topics included "neonatal nursing," "cooperative behavior," "practice guidelines," "medical staff," "education, nursing continuing," and "organization culture." Group 2 (see Figure, Supplemental Digital Content 3, http://links.lww.com/CIN/A48, illustrating group 2 of ICU communication topics) included research topics related to "child"; "intensive care unit, pediatrics"; "parents"; "infant"; "aged 80 and over"; "interdisciplinary communication"; "cross-sectional studies"; and "clinical competence." Group 3 (see Figure, Supplemental Digital Content 4, http://links.lww.com/CIN/A49, illustrating group 3 of ICU communication topics) included research topics such as "critical illness," "intensive care units," "aged," "professional family relations," "neonatal," "family," "survey and questionnaire," "qualitative research," and "nursing role."

Groups 4 to 10 were relatively smaller compared to groups 1 to 3 (see Figure, Supplemental Digital Content 5, http://links.lww.com/CIN/A50, illustrating groups 4–10 of ICU communication topics). Group 4 included "job satisfaction," "visitors to patients," "time factors," "empathy," and "hospital teaching." Group 5 included "hospital university," "family nursing," "reproductive results," "guideline adherence," and "pain management." Group 6 included "academic medical centers," "postoperative care," "age factors," and "information dissemination." Group 7 included "hypnotics and sedatives," "documentation," and "conscious sedation." Group 8 included "hospitals-pediatric" and "professional-patient relation." Group 9 included "professional anatomy" and "medical error." Group 10 included "nurse clinicians" and "nurse administrators."

DISCUSSION

This study investigated nursing-related ICU communication using the SNA approach to suggest directions for future research. To the best of our knowledge, this is the first study

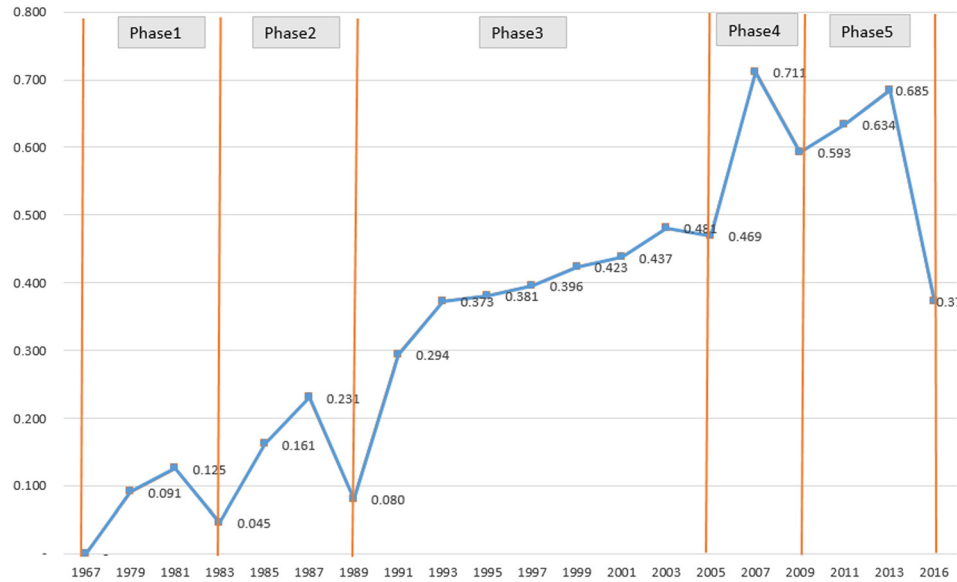

FIGURE 1. Phase setting by similarity.

to review the topic of communication in ICUs with data collected across a long period (approximately 48 years). Social network analysis is the application of graph theory to understand, categorize, and quantify relationships in a social network. It can be a great tool for improving analytic capabilities in any field, such as marketing, prediction, or healthcare.[18,19,21,26,27]

In this study, we defined five phases based on the passage of time and the use of keywords and confirmed the relationship with extracted keywords in each phase. In phase 1

Table 2. Newly Emerging Research Topics in ICU Communication

Keywords (MeSH Term)	1967–1982 (Phase 1)	1983–1988 (Phase 2)	1989–2004 (Phase 3)	2005–2008 (Phase 4)	2009–2016 (Phase 5)
Surveys and questionnaires	—	5	65	77	78
Middle aged	—	4	67	58	149
Intensive care units, neonatal	—	4	27	17	71
Aged	—	3	41	30	88
Nursing assessment	—	3	36	19	22
Attitude of health personnel	1	2	64	74	108
Family	—	2	52	22	43
Nurse-patient relations	—	2	48	25	40
Nursing methodology research	—	—	46	60	38
Infant, newborn	1	3	45	31	82
Professional-family relations	1	3	39	31	86
Interprofessional relations	4	2	38	34	35
Patient care team	1	1	31	20	59
Decision making	1	1	29	14	49
Stress, psychological	4	2	28	19	24
Clinical competence	1	—	26	28	35
Adaptation, psychological	1	1	25	27	19
Health knowledge, attitudes, practice	—	—	25	24	23
Nurse's role	—	—	24	60	50
Social support	—	—	18	40	32
Communication barriers	—	—	16	8	23
Cooperative behavior	—	—	14	23	40
Qualitative research	—	—	9	35	70
Health services needs and demand	—	—	8	34	15
Intensive care units, pediatric	—	—	9	21	36
Medical errors	—	—	3	10	9
Observation	—	—	1	5	11
Facial expression	—	—	—	5	6
Medication errors	—	—	—	5	5
Young adult	—	—	—	—	54
Interdisciplinary communication	—	—	7	8	46
Critical care nursing	—	—	—	—	38
Family nursing	—	—	2	3	25
Health care surveys	—	—	4	5	24
Guideline adherence	—	—	5	5	23
Nonverbal communication	—	—	4	—	14
Feasibility studies	—	—	1	—	14
Quality improvement	—	—	—	—	14
Checklist	—	—	—	—	12
Patient handoff	—	—	—	—	9
Patient safety	—	—	—	—	9
Tertiary care centers	—	—	—	—	9
Evidence-based practice	—	—	—	—	7

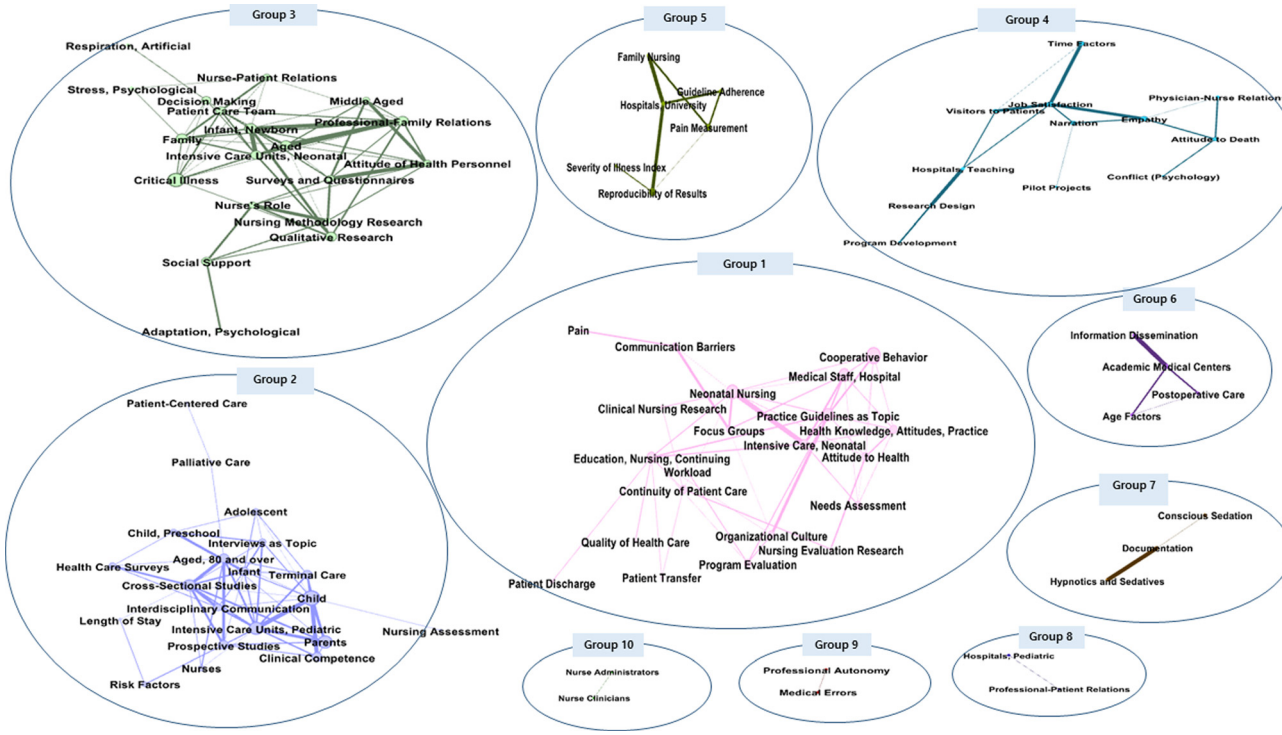

FIGURE 2. Ten groups of topics in ICU communication.

(1967–1982), keywords related to communication in ICUs appeared for the first time. In phase 2 (1983–1988), new keywords such as "surveys and questionnaires," "middle aged," and "intensive care unit, neonatal" appeared. In this period, mortality declined worldwide because of improvements in medical technology. Also, many descriptive research studies that measured the results of appropriate medical intervention as an objective indicator of mortality were conducted.[28–30]

In phase 3 (1989–2004), more topics emerged with new keywords such as "communication barrier" and "social support" than in the previous phases. Where there were communication barriers or extremely restricted communication between healthcare providers and patients with communication vulnerabilities (patients who could not speak due to surgery, such as brain surgery, tracheostomy, or mechanical ventilation, or elderly and very young patients), there was an increase in the incidence of adverse events and serious errors in critical care settings.[7] In these contexts, social support can decrease adverse health outcomes, such as lengthy hospital stays or mortality due to patients' maladaptive response to ICU treatment.[31] Consequently, further research is needed to identify strategies that can enhance the training of healthcare providers in effective nonverbal communication with vulnerable patients, so as to extend social support and prevent adverse outcomes.

In phase 4 (2005–2008), keywords such as "health service needs and demands" and "medical error" drastically increased. In the early 2000s, The Joint Commission International Accreditation System was introduced to improve healthcare and patient-centered care. In this context, research was conducted on patient safety reporting systems for the prevention of adverse events, the importance of communication with superiors, and leadership in communication enhancement.[13,32,33] In addition, with the development of health information technology, such as electronic health records and computerized physician order entry (CPOE), face-to-face communication in healthcare settings began to be replaced by mediating systems. This resulted in the emergence of studies comparing direct, face-to-face communication and indirect, mediating communication to verify the effectiveness of these communication systems.[34] For nurses, especially, many aspects of communication decreased within 3 months of CPOE implementation. Studies in several countries, including Australia, Denmark, France, and the United States, demonstrated that communication was disrupted after CPOE implementation because face-to-face communication was replaced by asynchronous communication.[35] However, there is a wide variety of communication channels available, including basic, face-to-face conversation; telecommunication channels such as the telephone or email; and computational channels such as the medical record. Asynchronous communication is not inherently interruptive, and if a communication is not urgent, such channels may be preferable when communicating with otherwise busy individuals.[35]

In phase 5 (2009–2016), searches related to "critical care nursing," "patient handoff," "quality improvement," "checklist," and "evidence-based practice" were common.

Most patients in ICUs experience severe problems that require complex care. Interdisciplinary communication therefore received more attention due to increasing healthcare complexity and severity of ICU illnesses. Moreover, comprehensive interdisciplinary care, coordination, and standardized, evidence-based practice may be achieved for patients with critical illness who require complex care.[36] The keywords "critical care nursing" and "patient handoff" were particularly prevalent during this phase. Due to the inherent risks when patients leave the ICU (eg, discharge or transfer), effective intershift information communication is necessary to ensure continuity and to improve quality of care. Future studies are needed to develop standardized guidelines that can improve communication protocol for medical personnel to establish safe delivery and proper healthcare during patient transfer.[37]

A total of 10 groups were clustered as a result of the network structure analysis in this study. Group 1 included related main research topics, such as "neonatal nursing" and "neonatal intensive care." Other related research topics appeared, such as "practice guideline," "patient discharge," "cooperative behavior," "medical staff," and "nursing continuing education." There is a significant need for neonatal ICUs to provide delicate care accompanied by attentive, nonverbal communication that involves skin-to-skin contact, facial expressions, and vocal inflection.[38] More important are needs assessments related to effective communication between neonates, parents, and healthcare providers, to improve quality of care.[39–41] To date, there are only a few studies that address the development of nonverbal communication guidelines or programs.[42] Accordingly, future studies are needed to improve this important communication aspect of ICU care to conduct effective interventions. One study of this problem highlighted the importance of communication in the transfer of patients to a general ward or during hospital discharge from an ICU. Adverse events in the transfer process are caused by insufficient or improper handover, including documentation exchanged by medical staff.[43,44] Future research might therefore include methodological studies to improve continuity of care and mitigate the effects of handoff on patient outcomes, such as mortality and readmission rates.

The research topics in group 2 mostly focused on "child intensive care units"; "intensive care units, pediatrics"; "parental care"; "terminal care"; and "length of stay," and were linked in the network. In pediatric ICU treatment, in particular, parents and family members are important healthcare providers. Since the pediatric ICU setting is separate from the regular ICU, medical staff engagement and parent participation lead to successful ICU communication.[45,46] Accordingly, patient-centered strategies to standardize and facilitate communication planning for families and healthcare providers are needed. Research topics such as "terminal care," "palliative care," and "aged 80 and over" were related to each other. With increased interprofessional collaboration, and a comprehensive approach to care by all clinicians, palliative care is being progressively accepted as an integral component of comprehensive care for critically ill patients. As a result, ethics consultation in palliative care leads to increased communication between healthcare providers, patients, and patients' families and may help to reduce the duration of stay in the ICU.[47] Further studies are needed to detect meaningful changes in family outcomes, and to provide cost-effectiveness analyses related to the connection between terminal or palliative care and duration of ICU stay.

Group 3 was mainly related to "critical illness" and focused on keywords such as "ICU, neonatal"; "family"; "stress, psychological"; and "patient care team." Owing to advances in childbirth practices and diagnostic methods, the number of high-risk neonatal ICU admissions has increased, and the mortality rate of neonates with very low birth weight (VLBW) has decreased.[48–50] These topics are closely related to emotions, stress, and social support for the parents of high-risk neonates.[51] Parents with VLBW neonates experience uncertainty, loss of control, and anxiety; therefore, researchers should consider effective communication strategies for them. With respect to these issues, qualitative research has focused on psychological symptoms, such as severe stress, posttraumatic stress, general anxiety, and depression in ICU patients.[52–54] Despite the existence of many quantitative studies on the topic, there has not been sufficient qualitative investigation, and no research on psychological intervention or its effectiveness were found. Research in these areas is therefore required in the future.

The nodes and edges of related keywords showed a marked increase in groups 1 to 3. By comparison, groups 4 to 10 presented weaker relationships than groups 1 to 3, and a number of connected topics were linked to show research trends in ICU communication. Groups 4 to 10 presented related keywords in the network, for example, "job satisfaction," "information dissemination," "documentation," "professional autonomy," "professional-patient relations," and "family nursing." These keywords indicate that studies related to ICU communication were conducted and show relationship between job satisfaction,[55] importance of records for communication,[56] professional autonomy at the time of decision making,[57] and family nursing in ICUs.[58]

Results of the analysis of trends in ICU communication research topics show that various keywords that may influence ICU communication have been used as research keywords and are related to each other. Through these keywords and relationships, we were able to describe research on ICU communication.

This study has some limitations. First, it was necessary to clarify the definition of the terms from the beginning of the study since subjective judgment can occur in the process of analyzing data. Second, various SNA indicators, such as closeness, betweenness, or cohesion, should be added to explain the characteristics of networks. Additionally, we focused only on nursing-related ICU communication. Therefore, future studies using various analysis methods are needed to identify research trends and to make a timely comparison of networks and various healthcare settings for communication studies.

CONCLUSION

Using chronological research trends, our study showed that recent studies of communication in ICUs have focused on patient handoff, quality improvement, and evidence-based practice. In addition, the keywords of the three largest groups among the 10 groups studied focused mostly on vulnerable patients, such as neonates, infants or children, patients who require palliative or terminal care, and their families and caregivers.

This study found that communication with patients and family caregivers in critical care settings, specifically ICUs, can be quite challenging for nurses and other healthcare providers. This study can help promote a systematic understanding of ICU communication research by identifying topic networks and thereby contributing to the future direction of ICU communication research and education.

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