

# Exploring the Knowledge Structure of Patient Safety in Nursing Using a Keyword Network Analysis

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Patient safety is a critical and long-standing issue in nursing research. The purposes of this study were to explore the knowledge structure of patient safety and to provide a direction for future research by offering new perspectives and a theoretical clarification of patient safety in nursing.

Keyword network analysis was performed by extracting keywords from abstracts of 6072 published articles. To reflect nursing perspectives, focus group interviews were conducted and Kim's typology consisting of four domains was used as the framework of analysis. Visualized knowledge structure showed avoiding medication error and preventing pressure ulcers or falls remain important topics within this research field. The distribution of core keywords as per four domains was in the following order: practice, client, environment, and client-nurse domain. Within the client domain, patients' harm-related core keywords were limited to physical harm. The detailed knowledge structure consisted of five themes: patient, preventable patient harm, practice, error, and environment. It comprised risk assessment for patients' characteristics and environmental elements surrounding patient and nursing practice, and risk management using information as knowledge-based nursing practice. Regarding further research, we suggest a multidimensional approach to patient harm, and the utilization of the client-nurse relationship and information systems as strategies for patient safety.

**KEY WORDS:** Data visualization, Knowledge, Network analysis, Nursing, Patient safety

Patient safety is one of the most important issues facing healthcare today. Since Nightingale<sup>1</sup> analyzed the causes of British troops' mortality rate and drastically reduced it by introducing hygiene practices and organization management in 1855, patient safety has been a long-standing topic in nursing research. Moreover, a report from the Institute of Medicine<sup>2</sup> stimulated research and discussion on patient safety issues. Along with the argument that a culture of tracking and criticizing individual responsibility for incidents related to patient safety should end, a systematic approach for identifying the factors influencing patient safety has been increasingly emphasized.<sup>3,4</sup> These trends allowed nursing researchers to adopt a more active approach toward patient safety issues and include organizational issues related to patient safety in the nursing research field.<sup>5</sup>

Previously, most studies focused on nurses' responsibility in narrow aspects of patient care, such as avoiding medication errors and preventing patient falls.<sup>6,7</sup> Since 2008, there has been increased nursing research on patient safety topics, such as communication, leadership, resource allocation, organizational culture, and information.<sup>4,8,9</sup>

Nurses, as healthcare professionals, are responsible for patient safety because they engage most closely with the patients. This enables them to be the first to detect a threat to patients' safety and stop a chain of events that may result in an error. They play a critical role in patient safety through their ability to collaborate, coordinate, and integrate the multiple aspects of the services within the care directly provided by nurses as well as across the care delivered by others.<sup>5</sup> Thus, patient safety-related clinical situations facing nurses have an individual, situational, and context-oriented nature. Nurses must be strategic users of knowledge to choose behavioral processes in these situations. Therefore, the knowledge structure should be identified to enable nurses to synthesize and apply it to patient safety.

Despite increasing interest and research on patient safety among nursing clinicians and researchers, no studies have been conducted that provide a comprehensive understanding of the knowledge structure for patient safety in nursing. As academic fields become more extensive and specialized, it is necessary to systematically analyze and understand their structure based on accumulated research.<sup>10</sup> Research methods, such as systematic literature reviews, have been used to integrate and analyze previous studies.<sup>11,12</sup> However, they have

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some limitations—for example, they cannot cover all the research available on patient safety in nursing because they focus on analyzing a specific topic. Furthermore, they are associated with several biases, including publication bias and selection bias, because they rely on the knowledge and considerations of a few experts. An alternative method to the research methods is the keyword network analysis (KNA), which examines the co-occurrence of words in a large amount of text data and investigates links to quantify and visualize the results.<sup>10</sup> Therefore, it provides a more comprehensive and objective overview of the current state of a research field and has been used to explore the knowledge structure of research fields in various disciplines,<sup>13</sup> including nursing.<sup>14</sup> This analysis can provide a possible direction for future research, offering new perspectives and a theoretical clarification of the field of patient safety.<sup>10,13</sup>

To provide a theoretical clarification of the academic field, the results of KNA need to be analyzed with a unique perspective of the discipline. Kim<sup>15</sup> proposed a metaparadigmatic typology as theoretical framework for analyzing interest phenomena or concepts of nursing research from a nursing perspective. Kim's typology includes four domains equivalent to four spheres of the empirical world where nursing-related phenomena can be located—the client, client-nurse, practice, and environment domains. By identifying a locus of concepts and phenomena within the four domains, nursing researchers may organize problems that nursing as a scientific discipline is trying to solve.<sup>15,16</sup>

## METHODS

### Keyword Network Analysis

Keyword network analysis is also referred to as a co-word analysis, semantic network analysis, and text network analysis. It is a quantitative content analysis method based on the characteristics of networks, which consists of nodes and links in a system. The nodes represent the components, and the links represent the relationships between the nodes. A KNA uses keywords as components that reflect scientific research themes as its core contents and the co-occurrence of the keywords as the relationship. Keyword network analysis is based on the assumption that a set of keywords can be extracted from text to represent its core contents. The text data of KNA that reflect the research itself may include the title, abstract, and author keywords. This study selected abstracts as the text data of the keyword network. An abstract reflects the article's core scientific research contents. Earlier works used the author keywords or the KeyWords Plus terms assigned by indexers to conduct the analysis. Currently, the technical developments in text mining make it possible to use words in the abstract or full text to do a co-word analysis.<sup>17</sup> This can reduce the indexer effects greatly. In this study, keywords were selected through refining words extracted from

abstracts, and the co-occurrence relationships were set based on “window size three or less,” which describes two keywords appearing side by side or with the other keyword in between two keywords in one abstract.<sup>18</sup> We constructed a keyword network based on the co-occurrence of English keyword pairs.

### Data Selection

To select text data for KNA, we retrieved journal articles published from January 1, 2008, to June 30, 2019, from three databases, including MEDLINE, EMBASE, and CINAHL.

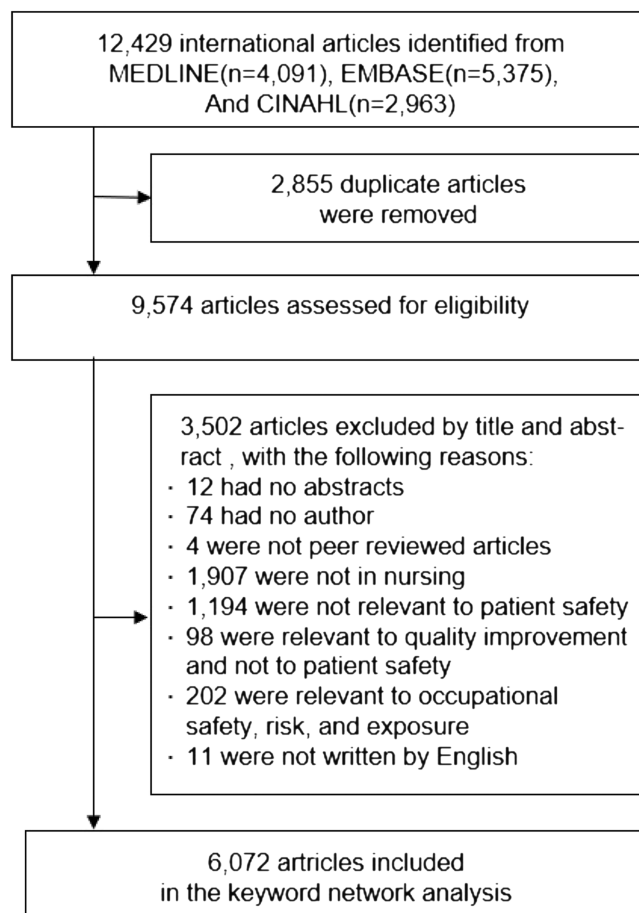
Our search strategy included a combination of terms including “patient safety,” “error,” “risk management,” “safety management,” “patient harm,” “near miss,” “healthcare-associated infection,” “fall,” “pressure ulcer,” and “nursing.” Moreover, we referred to previous studies that proposed strategies for searching articles on “patient safety”<sup>19,20</sup> and additionally on “healthcare-associated infection,” “falls in a healthcare institution,” and “pressure ulcer.”<sup>21–23</sup> We included “nursing” and “nurse” in the search strategy to limit the search to the nursing science field, focusing on only English articles for the analysis.

Of the 12 429 articles, we excluded 2855 duplications and 3502 articles irrelevant to patient safety or not written in English. Two researchers independently screened these articles based on the titles and abstracts. Finally, 6072 articles were selected for this analysis (Figure 1). The abstracts with publication year and title from 6072 articles were converted to an Excel list.

### Data Preprocessing

NetMiner software version 4.3 (Cyram, Seongnam, South Korea), a network analysis program, was used to perform KNA. This program includes several subprograms, including extracting words to be used as keywords from unstructured text and preprocessing extracted words to code into keywords suitable for network analyses. As a KNA analyzes the role and attributes of keywords, the quality of research results is determined by which words are selected as keywords.

The extracted words from the abstracts of the selected articles were varied, thereby necessitating preprocessing, including standardization, to ensure data quality and consistency. Stop-words such as pronouns, numbers, and adverbs were automatically deleted through the “unstructured text processing” of NetMiner. We excluded supplementary words or expressions that were irrelevant to the purpose of this study, including, for example, (1) terms related to the abstract form, such as “background”; (2) statistical terms, such as “*P* value”; and (3) words with inconsistent meanings or the most common words, such as “term,” “point,” or “view.” To code keywords suitable for a network analysis, we performed standardization by merging variants of the same term, such as synonyms or



**FIGURE 1.** Flowchart of the data selection process.

derivatives, into one relevant word. To determine the appropriateness of the refined keywords, we referenced the handbook by Hughes<sup>4</sup> in this process. To confirm whether the refined keywords reflected the core contents of a study, we reviewed abstracts and titles. After the preprocessing phase, a total of 15 495 keywords were extracted from the 6072 abstracts.

### Filtration

To identify the knowledge structure of patient safety nursing research, we examined the keyword distribution and confirmed the knowledge structure network using NetMinder. The frequency of a keyword refers to the number of times it occurs in all the included abstracts; the occurrence frequency of a keyword refers to the number of studies in which a keyword occurred; and the co-occurrence frequency refers to the frequency of a pair of keywords that occur simultaneously.

To simplify the network structure's visualization, each keyword was assigned as a node, and the links connecting the nodes were filtered. In filtering the nodes, keywords with a frequency of more than 30 and an occurrence frequency of

more than 25 were selected as keywords. Lastly, we excluded “nurse” or “nursing”—the most common terms in nursing research. In the process of filtering links, links with a co-occurrence frequency of 11 or greater were included in this analysis after two researchers performed multiple simulation rounds. It is recommended to determine the appropriate links with a co-occurrence frequency, enabling researchers to identify the main network structure and discover appropriate sub-theme groups through repeat simulations while considering the network's size or density.<sup>24,25</sup>

### Analysis of Knowledge Structure

We identified core keywords, network structures, and sub-theme groups using the network analysis program to identify patient safety knowledge. To identify core concepts or phenomena of patient safety nursing research, 100 core keywords were selected with a high degree of centrality. The values of degree centrality increase with the number of nodes directly connected in the network. Keywords with a high degree of centrality play a “hub” role with great influence on other

keywords in the network, which are regarded as core concepts or important themes in the research field.

To visualize the network structure composed of 100 core keywords, a spring map and a Pathfinder network (PFNet) were used. A spring map represents the node size based on the number of documents in which core keywords appeared, and PFNet is the network data summarizing major links between core keywords. Maps visualized with PFNet reveal detailed structures better than maps visualized in other ways and present the overall structure more clearly.<sup>24</sup>

To identify the detailed structure of the overall network, sub-theme groups were identified through a hierarchical clustering analysis. For hierarchical clustering, cohesion analyses, such as component analysis and eigenvector community analysis, were applied.<sup>26</sup> After the component analysis, the biggest component consisting of 391 keywords was selected for a community analysis. To explore which sub-themes belong to each group, an eigenvector community analysis was conducted stepwise. Two researchers interpreted the results and extracted themes from each group. All of the filtering and analysis procedures were validated by experts in network analysis programming and an experienced researcher who had performed a KNA.

To reflect the insights and experiences of experts, as well as nursing perspectives, two focus group interviews (FGIs) were conducted, based on the KNA results, in October 2019 after approval was received from the OOO University Institutional Review Board (KUIRB-2019-0204-01). The FGIs involved 11 participants divided into groups of 4-7 and were experts who had (1) completed a doctoral course in nursing science, (2) at least 3 years of experience in patient safety research or clinical practice, and (3) voluntarily consented to participation. To ensure that the interviews were conducted efficiently, the KNA results and the questionnaire on the results were sent to the participants via email 2 days before the FGI. The questionnaire included questions on the adequacy of themes extracted from sub-theme groups by two researchers and requested the classification of core keywords into four domains. The interviews were conducted in a quiet seminar room for approximately 110 minutes. The questions in the FGI included the following:

- Do the core keywords reflect the main topics or core concepts of patient safety that have been studied in the field of nursing?
- Is Kim's typology useful as a framework and analytic device for exploring the knowledge structure of patient safety?
- Are the themes extracted by the two researchers from each group appropriate?

The confirmation process about the adequacy of sub-themes proceeded based on the content agreed upon by the participants. The interviews were recorded. The observations of

verbal and nonverbal interactions during the FGIs were recorded as field notes. The data were analyzed using thematic analysis, comparing the content with the responses from the questionnaire. The classification of the core keywords into four domains required consensus among at least six participants, based on the participants' responses to the questionnaire.

Kim's<sup>15</sup> typology comprises client, client-nurse, practice, and environment domains. In the client domain, the emphasis is based on the knowledge of human phenomena from the nursing perspective, such as essentialist (essential experiences that human beings experience in ordinary states of living and growing), problematic (phenomena that are present in human beings as deviations from normal patterns of healthy living), and healthcare experiential (phenomena that arise from client's experiences in the healthcare system) phenomena or concepts. The client-nurse domain studies phenomena arising from a direct encounter between the client and the nurse in providing nursing care. The practice domain focuses on the nurses, and the concern is the cognitive and behavioral aspects of professional actions taken by nurses. It can be organized into two processes: the deliberation phase, denoted by the cognitive process, and the enactment phase, represented by the behavioral process. The nurses' professional role-related phenomena relevant to clinical nursing practice were conceptualized as a holistic focus. The environment domain focuses on the contextual aspect of human being and nursing practice. Environmental phenomena or concepts can be described as spatial, temporal, and qualitative meaning concerning physical, symbolic, and social components.<sup>15,16</sup> Additionally, Kim<sup>15</sup> mentioned that the holistic concepts in this domain took "the form of one's global surroundings having multiple yet coherent influences" and included healthcare environment and energy field concepts.

## RESULTS

A total of 15 495 words were extracted from the 6072 abstracts. After preprocessing and filtering, a network consisting of 430 keywords and 16 731 links was used for the analysis.

### Core Keywords and Network Structure

The core keywords of nursing research on patient safety identified keywords within the 100 high-degree centralities, including "patient," "care," "practice," "hospital," "medication," "safety," "error," "reporting," and "work."

To identify the network structure, the relationships between core keywords are visualized in Figure 2. Within the network structure, many core keywords were connected around core keywords such as "patient," "care," "practice," "prevention," "medication," "hospital," "error," and "reporting." "Patient" and "practice," which have links with several other core keywords, are connected through "quality" to "medication,"





Four participants responded that Kim's typology was useful for exploring the knowledge structure of patient safety, whereas one responded that it was not; meanwhile, six did not respond. Kim's typology was considered useful in identifying the domains wherein many and relatively few studies were conducted. The participants responded that classification using Kim's typology allowed them to identify that many studies have been conducted on the practice domain, whereas the client-nurse domain required further research. However, some responded that it was not useful. The reason is that many of the core keywords belonged to more than one domain, making classification difficult. Another reason is that the classification result may be subject to the person's bias who classifies it (see Supplemental Digital Content 1, <http://links.lww.com/CIN/A143>).

The core keywords classified by Kim's typology were restructured into four domains and visualized (Figure 3). The patient-care-quality-safety-culture and culture-safety-medication-error-reporting-event, as linkages of reconstructed network structure, were observed across the client, practice, and environment domains.

### Theme Groups

The detailed knowledge structure of patient safety nursing research comprised five theme and 47 sub-theme groups, with a four-step hierarchical structure (see Supplemental Digital Content 2, <http://links.lww.com/CIN/A144>). The five theme groups were "Patient," "Preventable patient harm," "Practice," "Error," and "Environment."

The first theme, "Patient," had "1-1 Patient with risk" and "1-2 Patient at risk" sub-themes. "1-1 Patient with risk" included sub-themes related to patients' characteristics and therapies that may have resulted in adverse events. "1-2 Patient at risk" included sub-themes related to the specific environment surrounding a patient receiving healthcare services. The sub-themes included Kim's environment domain-related keywords such as "ICU," "unit," and "ward." Additionally, "community" and "home" were included as keywords in this theme group.

The second theme, "Preventable patient harm," had sub-themes related to three types of patient harm and prevention measures for the same.

The third theme, "Practice," had sub-themes "3-1 Practice & knowledge," "3-2 Communication," and "3-3 Reporting." Among them, "3-1-2 knowledge" included keywords such as "knowledge," "EBP" (evidence-based practice), "informatics," and "competency."

The "4-3 Error management" sub-theme belongs to the "Error" theme and included the keywords "information," "source," and "resource."

The last theme, "Environment," had sub-themes related to the environment surrounding nursing practice, such as "5-1-1 Safety culture," "5-1-2 Workload," "5-2-1 Institutional process," and "5-2-2 Decision-making & Participation."

## DISCUSSION

### Core Keywords and Network Structure

These results showed that knowledge structure of patient safety focused on contents related to nursing practice, including medication, error, reporting, pressure ulcer, falls, and prevention. It indicates avoiding medication error and preventing pressure ulcers or falls remain important topics within this research field. Through risk identification considered as a crucial part of nursing practice, nurses play an important role in preventing errors, pressure ulcers, or falls.<sup>27-29</sup>

### Analysis Based on Kim's Typology

Kim's typology was useful for identifying domains of research topics that had been most actively researched and require further research. As per Kim's typology, the distribution of core keywords was the highest in the order of practice, client, environment, and client-nurse domains, respectively. This result showed that the client-nurse domain required further research. Considering that nurses work closest to patients and are responsible for their safety, they should utilize the client-nurse relationship as a patient safety strategy. A study on patient participation in patient safety reported that bedside shift reports reduced medical errors and improved patient safety by enabling patient participation and observation simultaneously. However, concerns included patient information leakage, confusion, and delayed task performance.<sup>30</sup> Vaismoradi et al<sup>31</sup> required consensus on patients' and nurses' role expectations (including the scope of patients' participation and questioning styles) during patient participation. Studies on patients' and nurses' role expectations are required to utilize the client-nurse relationship as a patient safety strategy.

Through core keywords related to patient harm within the client domain, it was identified that nursing research on patient harm was limited to physical harm. Some studies mentioned that physical constraints applied to prevent falls may cause physical as well as psychological harm in patients, such as circulatory disturbance, depression, and anger.<sup>32,33</sup> Thus, a multidimensional approach to patient harm in nursing research is required, considering psychological, social, and spiritual harm.

The 48 core keywords, with no classification, require the evolution of Kim's typology as a theoretical framework for patient safety. The keywords mostly related to organizational policy, performance, team members, education, and environmental elements surrounding nursing practice. Thus, Kim's typology must be refined further to provide appropriate solutions to the problems encountered by nurse clinicians, educators, and administrators involved in patient safety.

In Figure 3, "error" was located within the practice domain and connected with core keywords located within the client, practice, and environment domains. It signifies that the errors are phenomena occurring within nursing practice

and can be theoretical related to phenomena related to the client, practice, and environment domains. Based on consequences of patient harm due to errors, errors were classified as near-miss, errors that may cause temporary harm, or errors that may cause permanent harm.<sup>34</sup> Medication errors remain one of the leading threats to patient safety. In the arena where clinical nurses practice, medication remains an important task, consuming up to 40% of their work time and entailing significant responsibility.<sup>35</sup> However, for fear of accusations, medication errors have been underreported.<sup>36</sup> Studies reported that a positive attitude toward incident or error reporting was related to nurses' positive perceptions about safety culture and work environment.<sup>28,37</sup>

Through the core keywords classified into the subdomains of the practice domain and linked across other domains within the reconstructed network structure, the essence of nursing practice for patient safety was identified to improve nurses' informatics competency for controlling the relevant situational and behavioral processes, ultimately enhancing nursing quality.

## Theme Groups

### *"Patient" Theme*

It had "1-1 Patient with risk" and "1-2 Patients at risk" sub-themes. This indicates that nursing assessment for patient safety has been performed by detecting risk factors related to the patients' characteristics, therapies, and environmental elements surrounding the patient that threaten patient safety. To improve patient safety, Giuliano<sup>38</sup> suggested nursing surveillance that assesses patient's risk, recognizes changes in the patient's clinical status, interprets the clinical implications of these changes, and decides if actions are required. The healthcare environments, including specific physical environments (medical devices or facilities such as ICUs), and impaired social environments (separated from family and friends) can cause infection, withdrawal, and confusion in patients.<sup>15</sup> One approach to patient safety is a thorough assessment of environmental risk factors surrounding the patient to identify patients at risk. Thus, we suggest research on effective surveillance processes that nurses assess and analyze data on not only patient's condition change but also the environment surrounding the patient. Through keywords such as "community" and "home," microscopic expansion of the research topic from inpatients to the local community was also identified.<sup>39</sup>

### *"Preventable Patient Harm" Theme*

It had sub-themes related to three types of patient harm and prevention activities for them. As more types of harm have come to be regarded as preventable, pressure ulcers, falls, and urinary catheter infections have been regarded as

"unacceptable." However, Ayello et al<sup>40</sup> reported that unavoidable pressure ulcers were related to cardiopulmonary status, hemodynamic stability, medical devices, terminal illness, and nutrition.

Prevention activities include assessing, discerning, and classifying risks and providing restraints, bundles, and guidelines.<sup>41,42</sup>

### *"Practice" Theme*

It had sub-themes "3-1 Practice & knowledge," "3-2 Communication," and "3-3 Reporting." A central strategy for patient safety in nursing is the systems approach.<sup>3</sup> The systems approach relies on the reporting of adverse events to maximize organizational learning and prevent the recurrence of incidents. To promote nurses' incident reporting, Ammouri et al<sup>43</sup> suggested cooperative teamwork, feedback, and communication about errors. "5-1-2 Knowledge" included keywords such as "knowledge," "EBP," "informatics," and "competency." This indicates that informatics competency is required to improve nursing practice for patient safety. Abdrbo<sup>44</sup> reported that nursing informatics and patient safety competencies are significantly correlated. Some studies recommend the effective use of extensive information, including literature, healthcare records, and reporting data, to improve patient safety.<sup>43,45</sup> Data-based information management using computers and the Internet may be used as a technological instrument to improve patient safety. Nurses must utilize technological instrument to support safe nursing practices that are optimally informed and knowledge-based.<sup>46</sup> Thus, we suggest further research on the utilization of information system as a strategy for improving nursing practice for patient safety.

### *"Error" Theme*

The "error management" sub-theme belonged to this theme, which included the keywords "information" and "workflow." This means that workflow-improvement studies focused on information usage to manage errors were performed. Information processing can be applied to patient safety system design, but an understanding of error occurrence and service standardization is needed when using such an element (information processing) in improvements.<sup>47</sup>

Considering that "error" was classified into Kim's practice domain and linked to "practice" via "quality," "error" is a nursing practice phenomenon, and error management can be conceptualized within the practice domain as a strategy for improving nursing practice. We propose utilization of information related to service standardization as an error management strategy.

### *"Environment" Theme*

It had sub-themes related to the environment surrounding nursing practice, such as "Safety culture," "Workload," "Institutional process," and "Decision-making & Participation." The environmental elements that threaten



patient safety included communication failure among professionals and limited support from colleagues and managers (social environment), excessive environmental confusion (physical environment), and the nurse-patient ratio (work environment).<sup>28,48,49</sup> To improve nursing practice for patient safety, some studies suggested developing guidelines, building a patient classification system, and establishing a supporting system for nurses' knowledge-based decision making.<sup>41,45,50</sup>

This study has the following limitations. First, there is uncertainty about the scope and amount of literature chosen for the analysis. The extracted keywords can vary depending on how the literature scope is decided. We referenced previous studies and consulted literature search experts to establish a search strategy that suited our study objectives and could be verified objectively. Second, there is uncertainty about the number of keywords and links for the network analysis. The filtering process needed to obtain KNA results that could be interpreted easily. This study was conducted in consultation with a researcher who had performed a KNA previously and experts in network analysis programing. Third, only articles in English were considered. Lastly, there are limitations on providing contextual information (where concept belongs) because this study was conducted to classify concepts (keywords) extracted from text data using KNA into four domains. Therefore, there are probabilities that the bias of the person involved (placed the core concepts in the theoretical framework) may affect the result. Hereupon, this study has tried to reduce those biases by reflecting the insights and consensus of many experts through FGIs rather than relying on the insights of a few researchers.

## CONCLUSION

This study provides a comprehensive understanding of the knowledge structure of patient safety based on a KNA. The first finding was that avoiding medication errors and preventing pressure ulcers or falls remains an important topic in patient safety nursing research. Second, risk assessment was performed by collecting data on the characteristics of the patient and environmental elements surrounding the patient and nursing practice. Third, nursing practice for risk management included reporting, communication, and knowledge-based practice of nurses with informatics competency. Further research on the use and development of information systems is required to implement the systems approach as a strategy for patient safety.

It provides a theoretical clarification on the nursing problems in patient safety based on Kim's typology. It was useful in finding the domain of research topics that require further research and identifying the limited boundaries and unconsidered dimensions of an interested topic. The findings were that the client-nurse domain required further research, and

the topics on patient harm within the client domain were limited to physical harm. Nevertheless, 48 core keywords, with no classification, require the evolution of Kim's typology to provide solutions to the problems encountered by nurse clinicians, educators, and administrators in patient safety, and the emerging problems in related areas.

Regarding further research, we suggest (1) a multidimensional approach to patient harm, considering psychological, social, and spiritual harm; and (2) utilization of the client-nurse relationship and information systems as strategies for improving patient safety.

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