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REVIEW ARTICLE

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The Effects of Simulation-Based Disaster Nursing Education: A Scoping Review

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Purpose: This scoping review examined the characteristics and educational effects of simulation-based disaster nursing education programs for nursing students and nurses and aimed to provide foundational evidence for future curriculum design and research. **Methods:** Following Joanna Briggs Institute methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews, we searched four international and four Korean databases for studies published between January 2010 and December 2025. Studies were selected using the population, concept, and context framework and were limited to simulation-based educational interventions for disaster situations that reported quantitative learning outcomes. Twenty-four experimental or quasi-experimental studies with control groups met the inclusion criteria and were analyzed. **Results:** Most studies included nursing students, although several involved practicing nurses. Simulation modalities included online and virtual simulations, high-fidelity manikins, standardized patients, tabletop exercises, and blended formats, and addressed scenarios such as earthquakes, mass-casualty incidents, hazardous events, and infectious disease outbreaks. Educational outcomes were grouped into cognitive, affective, and performance domains. Across studies, improvements were frequently reported in disaster-related knowledge, self-efficacy, performance competency, and learning motivation; however, evidence for long-term retention, teamwork, and interprofessional collaboration remained limited. **Conclusion:** Simulation-based disaster nursing education may strengthen integrated disaster response competencies among nursing students and nurses. Structured programs incorporating pre-learning, scenario-centered practice, debriefing, and opportunities for repeated exposure may support competency development. Further research is needed to evaluate long-term and team-based outcomes and to develop multidisciplinary programs that more closely reflect real-world disaster contexts.

Key Words: Disaster nursing; Nursing education; Simulation training; Nursing students

INTRODUCTION

Disasters are internationally defined as events that severely disrupt the functioning of a community or society and create conditions that exceed the affected population's capacity to cope using its own resources and response capabilities [1]. They may be classified by cause as natural disasters, such as earthquakes, floods, typhoons, and infectious disease pandemics, or as human-induced or technological disasters, including industrial accidents, chemical or radiological incidents, and terrorism [2]. In recent years, complex disasters involving interacting hazards

have become more frequent because of climate change, urbanization, and increasingly advanced industrial systems [3]. Such events can cause large-scale loss of life within a short period and place substantial burdens on society, particularly on healthcare systems. Technological and human-induced disasters may also produce long-term health consequences and substantial social and economic losses [4]. These features underscore the need for resilience at the national and community levels, preparedness within healthcare systems, and proactive training for professionals involved in disaster response and recovery [5].

Nurses are key healthcare professionals who help maintain healthcare-system functioning during disasters. They are deployed from the early stages of a disaster and serve as frontline responders with critical responsibilities, including triage, emergency care, severity assessment, ongoing nursing care, resource allocation, and communication and coordination within healthcare teams [6,7]. In large-scale disasters, nurses must manage multiple patients simultaneously under severe time and resource constraints. Their clinical judgment, situational awareness, and team-based collaboration are therefore central to effective disaster response and patient survival [8]. To perform these roles effectively, nurses need an educational foundation that supports the systematic development of disaster response competencies before disasters occur. However, nursing students and practicing nurses have very limited opportunities to learn directly from real disaster situations. The unpredictable course of large-scale disasters, together with safety concerns and ethical constraints, makes direct participation in real-world disaster settings impractical for educational purposes [9]. Simulation-based education has therefore been widely adopted in nursing education to address these limitations.

Simulation-based education reproduces disaster-like situations in a controlled environment, allowing learners to practice decision-making and nursing performance repeatedly [10]. This approach helps learners move beyond knowledge acquisition and develop core competencies needed in disaster situations, including critical thinking, clinical judgment, team-based communication, and effective performance under stress [11]. Previous studies have reported multiple educational outcomes associated with simulation-based learning in nursing education. Evidence suggests that simulation-based education improves knowledge and technical performance among nursing students and practicing nurses and has positive effects on self-efficacy and learning satisfaction [8,12,13]. Disaster nursing simulations have also been shown to enhance disaster nursing competencies, team-based communication in complex and time-pressured situations, confidence in disaster response, and willingness to participate in such response [12,14,15]. Recent studies have evaluated high-fidelity simulation, standardized patients, and virtual reality across complex disaster scenarios, including mass-casualty incidents, natural disasters, technological disasters, and infectious disease outbreaks [10,12,15-17]. These studies have reported significant improvements in disaster preparedness, disaster nursing competencies, triage decision-making ability, and confidence in crisis response after simulation-based education [6,7]. Together, these findings suggest that simulation-based education may support the development of integrated competencies required in real-world disaster situations, rather than merely transmitting knowledge.

Although many studies have reported positive educational outcomes of simulation-based disaster nursing education, single-group pre-post designs remain common, limiting rigorous evaluation of intervention effects. Heterogeneity in research designs and outcome measures also makes findings difficult to compare and interpret across studies [6,12]. In addition, evaluations have often emphasized short-term cognitive outcomes, such as knowledge acquisition and learning satisfaction, rather than outcomes that more directly reflect disaster response competencies in real-world settings [6,12]. Therefore, this scoping review focused on quantitative studies that evaluated simulation-based disaster nursing education using experimental or quasi-experimental designs with control groups. We aimed to analyze the general characteristics of intervention studies on simulation-based disaster nursing education among nursing students and nurses, including program components, educational strategies, and reported educational outcomes. Ultimately, this review provides foundational evidence for designing and implementing disaster nursing simulation education programs and identifies current evidence and research trends in this field.

METHODS

1. Study Design

This scoping review was conducted to identify the program characteristics and educational effects of simula-

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tion-based disaster nursing education for nursing students and nurses. The review followed the five stages proposed by Arksey and O'Malley [18]: (1) identifying the research question; (2) identifying relevant studies; (3) selecting studies; (4) charting the data; and (5) collating, summarizing, and reporting the results. The literature review was conducted according to the scoping review guidelines of the Joanna Briggs Institute (JBI) [19], and the results were reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [20]. The protocol for this scoping review was registered on the Open Science Framework (DOI: 10.17605/OSF.IO/GQFVZ).

A scoping review methodology was used to provide a comprehensive overview of the characteristics, educational strategies, and reported outcomes of simulation-based disaster nursing education. Given the diversity of disaster contexts, participant groups, simulation modalities, and outcome measures in the literature, this approach was appropriate for examining the existing evidence and identifying research trends. Accordingly, the review mapped and described the available evidence rather than quantitatively synthesizing intervention effects or determining overall effectiveness.

2. Identifying the Research Question

This study used the Population, Concept, and Context framework proposed by JBI to establish the eligibility criteria for study selection [19]. The population comprised nursing students and nurses who directly participated in simulation-based disaster nursing education programs. The concept included disaster-related educational programs using simulation that reported learner educational outcomes. The context was restricted to educational programs designed to improve nursing competencies in disaster situations, including disaster response, triage, decision-making, and teamwork. Educational topics were not limited by disaster type; however, only studies with clearly defined educational purposes and learning outcomes were included. Based on these criteria, the primary research question was: "What are the educational characteristics and learning outcomes of simulation-based disaster nursing education programs for nursing students and nurses?"

3. Identifying Relevant Studies

The literature search for this scoping review was conducted in January 2026. After publication of the International Council of Nurses Framework of Disaster Nursing Competencies in 2009, disaster nursing education gained increasing recognition as a key area of nursing education [21]. Accordingly, this review searched for relevant literature published between January 2010 and December 2025 to capture developments after publication of the framework.

The international databases searched were PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Central Register of Controlled Trials (CENTRAL), and Excerpta Medica Database (Embase). The search strategy combined four concept groups using the Boolean operator AND: (1) nurs* OR "nursing student*" OR "undergraduate nursing student*"; (2) "education" OR "learning" OR "training"; (3) "simulation" OR "scenario-based" OR "high-fidelity"; and (4) disaster OR "disaster nursing" OR "emergency" OR "mass casualty" OR "triage."

The Korean databases searched were Research Information Sharing Service (RISS), Korean Studies Information Service System (KISS), DBpia, and KMbase. The South Korean database search strategy was based on the international strategy, with minor modifications or simplifications to accommodate the search functions of each database. Searches were conducted using combinations of Korean-language keywords corresponding to the four concept groups (e.g., the Korean equivalents of "nursing student," "nurse," "simulation," "disaster," "disaster nursing," "mass casualty," and "triage"), according to the search functions of each database. Detailed search strategies for each database, including the complete Boolean queries, search fields, controlled vocabulary where applicable, and search limits, are provided in Supplementary Table 1.

4. Study Selection

This scoping review included studies that examined the characteristics and educational effects of simulation-based disaster nursing education programs for nursing students and practicing nurses. Eligible studies applied educational interventions to these populations and used simulation-based education to improve nursing competencies in disaster situations, including disaster response, triage, de-

cision-making, and teamwork. Included studies also reported at least one quantitative learning outcome, such as knowledge, skills, attitudes, or self-efficacy.

Included studies were limited to peer-reviewed articles published in Korean or English. Eligible designs were experimental or quasi-experimental studies with a control group. Although scoping reviews may include a wide range of study designs, the JBI framework allows reviewers to include or exclude specific designs depending on the purpose and research question [19]. Therefore, to enable objective comparison of learning outcomes in simulation-based disaster nursing education programs, this review included only quantitative comparative studies that clearly reported intervention effects.

Studies were excluded if they did not involve nursing students or nurses, were unrelated to disaster contexts, or did not include an educational intervention. Studies that did not report quantitative learning outcomes were also excluded, as were gray literature sources such as theses, conference abstracts, and non-peer-reviewed reports. In addition, single-group studies, qualitative studies, descriptive surveys, meta-analyses, literature reviews, animal studies, pilot studies, and studies without available full text were excluded. After duplicate records were removed, two researchers independently screened the titles and abstracts of all identified studies according to the inclusion and exclusion criteria. Studies that appeared eligible were then assessed through full-text review by the same two researchers. Disagreements about study eligibility were resolved through discussion and consensus.

A total of 925 studies were identified through database searches: 215 from PubMed, 146 from CINAHL, 268 from CENTRAL, 127 from Embase, 78 from RISS, 26 from KISS, 53 from DBpia, and 12 from KMbase. After 485 duplicate records were removed, 440 records remained. Of these, 92 gray literature records, including theses, conference abstracts, and non-peer-reviewed reports, were excluded because they did not meet the publication-type eligibility criterion. Consequently, 348 studies remained for title and abstract screening. During this stage, 276 studies were excluded for not meeting the inclusion criteria, leaving 72 studies for full-text review. Of these, 11 were excluded because full texts were unavailable, 21 because they did not include disaster-related simulation interventions, and 16 because they did not report quantitative outcomes. Ultimately, 24 studies met the inclusion criteria and were included in this scoping review (Figure 1).

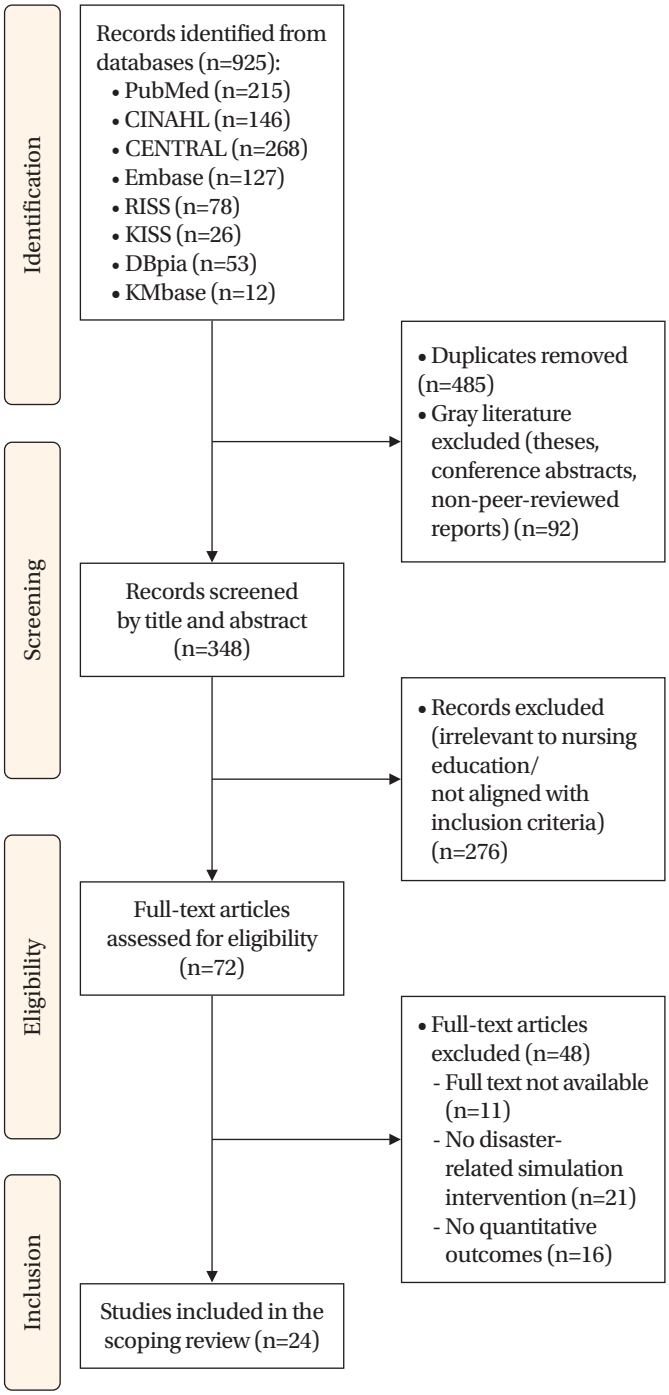

Figure 1. Flow diagram of literature selection.
CENTRAL = Cochrane Central Register of Controlled Trials; CINAHL = Cumulative Index to Nursing and Allied Health Literature; Embase = Excerpta Medica; KISS = Korean Studies Information Service System; RISS = Research Information Sharing Service.

5. Charting the Data

The study selection process followed scoping review procedures, and the flow of study selection was reported ac-

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cording to PRISMA-ScR [20]. Data extraction was performed independently by two researchers, a professor with a doctoral degree in nursing and a doctoral candidate in nursing, using the standardized data extraction tool recommended by JBI [19]. Extracted data included general study characteristics, such as author, year of publication, and country; participant characteristics; study design; characteristics of the simulation-based intervention; and educational outcomes. Discrepancies between researchers were resolved through discussion and consensus. To ensure completeness of the included evidence, the reference lists of selected articles were also manually reviewed to identify additional relevant studies; however, no additional eligible studies were identified through this process.

6. Collating, Summarizing, and Reporting the Results

The extracted data were categorized and descriptively summarized according to the objectives of this scoping review. Studies were grouped into three domains: (1) structural characteristics of simulation-based disaster nursing education interventions, including implementation settings, participant characteristics, disaster scenarios, and simulation modalities; (2) design characteristics of educational programs, including educational objectives, scenario and technological components, teaching and learning strategies, simulation implementation strategies, evaluation components, and application of learning theories; and (3) educational outcomes, including disaster-related knowledge and knowledge retention, self-efficacy and confidence, performance competency, attitudes, beliefs, learning motivation, and process- and learning-transfer-related indicators. Within each domain, similarities and differences across studies were compared and analyzed to identify key trends and recurring patterns in simulation-based disaster nursing education research.

7. Ethical Considerations

This study did not involve human participants and was therefore exempted from review by the Public Institutional Review Board designated by the Ministry of Health and Welfare of Korea (No. P01-202602-01-061).

RESULTS

The classification criteria used throughout this review are provided in the Supplementary Material.

1. General Characteristics

A summary of the general characteristics of the 24 studies included in this review is presented in Table 1 and Supplementary Table 2.

1) Publication year and country distribution

Among the 24 included studies, publication years were distributed as follows (Supplementary Data 1): one study each in 2013 (4.2%) [A24], 2015 (4.2%) [A23], 2018 (4.2%) [A22], 2019 (4.2%) [A21], and 2020 (4.2%) [A20]; four studies in 2021 (16.7%) [A16-19]; six studies in 2022 (25.0%) [A10-15]; one study in 2023 (4.2%) [A9]; four studies in 2024 (16.7%) [A5-8]; and four studies in 2025 (16.7%) [A1-4].

By country, eight studies (33.3%) were conducted in South Korea [A1,A4-7,A9,A13,A21], followed by seven studies (29.2%) in the United States [A11,A17,A18,A20,A22-24] and four studies (16.7%) in China [A8,A10,A16,A19]. Two studies (8.3%) were conducted in Iran [A12,A15], and one study each (4.2%) was conducted in Taiwan [A14], Turkiye [A2], and Indonesia [A3].

2) Participants and sample size

Most studies targeted nursing students, accounting for 16 studies (66.7%) [A1-5,A9,A10,A12,A15-18,A21-24], whereas seven studies (29.2%) targeted nurses [A6-8,A13,A14,A19,A20]. One study (4.2%) used a multidisciplinary sample comprising nursing students, graduate students in public health, and graduate students in social welfare [A11].

Sample sizes ranged from 30 to 213 participants. Three studies (12.5%) included fewer than 50 participants [A13,A15,A24], whereas 13 studies (54.2%) included 50-99 participants [A1-4,A6,A7,A9,A12,A14,A16,A18,A20,A21]. Four studies(16.7%) included 100-149 participants [A5,A17,A19,A23], three studies (12.5%) included 150–199 participants [A8,A10,A22], and one study (4.2%) included 200 or more participants [A11].

3) Disaster types and simulation modalities

Analysis by disaster type showed that earthquake-related disasters were the most frequently addressed, accounting for eight studies (33.3%) [A2,A3,A5,A6,A8,A10,A12,A16]. Disasters involving chemical, biological, radiological, nuclear, or explosive events, as well as hazardous materials, accounted for five studies (20.8%) [A13,A14,A17,A22,A23]. Mass-casualty incidents, primarily focused on triage, were

Table 1. Characteristics of the Included Studies

Studies	Countries	No. of participants	Disaster types	Simulation modalities	Study no.
Kim et al. (2025)	South Korea	3rd–4th-year nursing students (n = 67; Exp: 33, Cont: 34)	MCI	Exp: online simulation Cont: lecture-based education	A1
Genc et al. (2025)	Turkiye	4th-year nursing students (n = 74; Exp: 36, Cont: 38)	Earthquake disaster	Exp: face-to-face simulation Cont: lecture-based education	A2
Emaliyawati et al. (2025)	Indonesia	Undergraduate nursing students (n = 94; Exp: 47, Cont: 47)	Earthquake disaster	Exp: face-to-face simulation Cont: lecture-based education	A3
Seok and Park (2025)	South Korea	3rd-year nursing students (n = 52; Exp: 25, Cont: 27)	MCI	Exp: face-to-face simulation Cont: no intervention	A4
Park and Hwang (2024)	South Korea	4th-year nursing students (n = 140; Exp: 70, Comp: 35, Cont: 35)	Earthquake disaster	Exp: face-to-face simulation Comp: lecture-based education Cont: no intervention	A5
Choi and Choi (2024)	South Korea	Clinical and community nurses (n = 58; Exp: 30, Cont: 28)	Earthquake disaster	Exp: online simulation Cont: self-learning (e-book)	A6
Ko and Choi (2024)	South Korea	Clinical nurses (n = 93; Exp: 45, Cont: 48)	Infectious disease (COVID-19)	Exp: online simulation Cont: self-learning (text-based education)	A7
Hu et al. (2024)	China	New EMT nurses (n = 198; Exp: 101, Cont: 97)	Earthquake disaster	Exp: online simulation Cont: lecture-based education	A8
Lee and Jung (2023)	South Korea	3rd-year nursing students (n = 54; Exp: 27, Cont: 27)	Complex disaster	Exp: face-to-face simulation Cont: lecture-based education	A9
Hu et al. (2022)	China	Nursing students (n = 158; Exp: 78, Cont: 80)	Earthquake disaster	Exp: online simulation Cont: lecture-based education	A10
Wong et al. (2022)	United States	Interprofessional students (n = 213; Exp: 63, Cont: 150)	Complex disaster	Exp: online simulation Cont: face-to-face simulation	A11
Masoumian Hosseini et al. (2022)	Iran	3rd-year nursing students (n = 60; Exp: 30, Cont: 30)	Earthquake disaster	Exp: blended simulation Cont: case-based education	A12
Kim and Choi (2022)	South Korea	Clinical nurses (n = 30; Exp: 10, Comp: 10, Cont: 10)	CBRNE (chemical)	Exp: face-to-face simulation Comp: lecture-based education Cont: handout	A13
Chang et al. (2022)	Taiwan	Emergency nurses (n = 67; Exp: 32, Cont: 35)	CBRNE (chemical)	Exp: online simulation Cont: face-to-face simulation	A14
Ghahremani et al. (2022)	Iran	4th-year nursing students (n = 40; Exp: 20, Cont: 20)	Bioterrorism	Exp: face-to-face simulation Cont: workshop/lecture	A15
Ma et al. (2021)	China	Nursing students (n = 51; Exp: 25, Cont: 26)	Earthquake disaster	Exp: face-to-face simulation Cont: scenario-based simulation	A16
Smith et al. (2021)	United States	4th-year nursing students (n = 121; Exp: 61, Cont: 60)	CBRNE (decontamination)	Exp: online simulation Cont: high-fidelity simulation	A17
Wiese et al. (2021)	United States	Nursing students (n = 80; crossover: both interventions)	Natural disaster	Exp: online simulation Cont: face-to-face simulation	A18
Zhang et al. (2021)	China	Clinical nurses (n = 120; Exp: 60, Cont: 60)	Infectious disease (COVID-19)	Exp: blended simulation Cont: conventional education	A19
Gray et al. (2020)	United States	NICU & pediatric emergency nurses (n = 60; Exp: 30, Cont: 30)	Natural disaster (evacuation)	Exp: online simulation Cont: multimedia lecture	A20
Kim et al. (2019)	South Korea	4th-year nursing students (n = 70; Exp: 35, Cont: 35)	Complex disaster	Exp: face-to-face simulation Cont: no intervention	A21
Smith et al. (2018)	United States	Nursing students (n = 172; Exp: 59, Comp: 58, Cont: 55)	CBRNE (decontamination)	Exp: online simulation Comp: online simulation Cont: written instructions	A22
Farra et al. (2015)	United States	Nursing students (n = 106; Exp: 54, Cont: 52)	CBRNE (decontamination)	Exp: online simulation Cont: web-based education	A23
Farra et al. (2013)	United States	Nursing students (n = 47; Exp: 22, Cont: 25)	MCI	Exp: online simulation Cont: web-based education	A24

CBRNE = chemical, biological, radiological, nuclear, and explosive; Comp = comparison group; Cont = control group; COVID-19 = coronavirus disease 2019; e-book = electronic book; EMT = emergency medical technician; Exp = experimental group; MCI = mass casualty incident; NICU = neonatal intensive care unit.

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addressed in three studies (12.5%) [A1,A4,A24], and complex disasters were also addressed in three studies (12.5%) [A9,A11,A21]. Two studies (8.3%) addressed infectious disease-related disasters, including coronavirus disease 2019 [A7,A19], and two studies (8.3%) focused on natural disasters [A18,A20]. One study (4.2%) addressed bioterrorism-related disasters [A15].

Simulation modalities were classified according to the primary mode of educational delivery. Online simulation was the most frequently used modality, appearing in 13 studies (54.2%) [A1,A6-8,A10,A11,A14,A17,A18,A20,A22-24]. Standardized patient, manikin, and scenario-based face-to-face simulations were used in nine studies (37.5%) [A2-5,A9,A13,A15,A16,A21], and blended simulations combining online and offline components were reported in two studies (8.3%) [A12,A19].

2. Components and Educational Strategies of Simulation-Based Disaster Nursing Education Programs

A summary of the components and educational strategies of the simulation-based disaster nursing education programs identified in this review is presented in Table 2.

1) Program components

(1) Types of educational objectives

Analysis of educational objectives showed that programs aiming to improve disaster nursing knowledge and theoretical understanding, including literacy and knowledge retention, were the most common, accounting for 17 studies (70.8%) [A1-3,A8-10,A12,A13,A15,A16,A18-24]. Programs aiming to enhance disaster response performance and technical skills were equally common, also accounting for 17 studies (70.8%) [A1,A4-7,A9,A11,A13,A15-23]. Programs aiming to improve emotional attitudes, self-efficacy, and confidence in disaster response accounted for 14 studies (58.3%) [A1,A3-5,A7,A13-18,A20,A21,A23], whereas those focusing on decision-making ability, critical thinking, and judgment accounted for 12 studies (50.0%) [A2,A4-12,A16,A18]. Programs targeting disaster preparedness accounted for eight studies (33.3%) [A2,A5,A9,A14,A15,A18-20]. Programs addressing learning motivation, learning satisfaction, and self-directed learning accounted for six studies (25.0%) [A3,A6-8,A10,A17], and those focusing on non-technical skills, such as communication, collaboration, and leadership, accounted for five studies (20.8%) [A6,A7,A11,A12,A20].

(2) Scenario components

Analysis of scenario components showed that scenarios incorporating mass-casualty triage were the most common, accounting for 11 studies (45.8%) [A1,A4,A5,A8,A9,A11,A12,A14,A16,A18,A24]. Scenarios reflecting all phases of disaster management, including preparedness, response, and recovery, accounted for seven studies (29.2%) [A2,A3,A9,A11,A16,A18,A21], and scenarios focusing on hospital-based disaster response also accounted for seven studies (29.2%) [A7,A9,A14,A15,A19-21]. Scenarios incorporating decontamination procedures accounted for six studies (25.0%) [A14,A15,A17,A22-24], and scenarios including psychological first aid also accounted for six studies (25.0%) [A5-7,A12,A13,A16].

(3) Technical components

Based on the technology and media used to implement simulation scenarios, screen-based simulations were the most frequently reported technical component, appearing in 13 studies (54.2%) [A2,A3,A6-8,A10-12,A18,A20,A22-24]. In these simulations, learners engaged with content through computer, tablet, or mobile-device screens using web-based or online platforms. Game-based simulations, including serious games, were used in seven studies (29.2%) [A2,A6-8,A10,A12,A16]. Head-mounted display-based three-dimensional virtual reality simulations, in which learners performed tasks through physical interaction in an immersive virtual environment, were reported in five studies (20.8%) [A1,A14,A17,A19,A22], and standardized patient-based simulations were also reported in five studies (20.8%) [A5-7,A12,A13]. Tabletop simulations were reported in four studies (16.7%) [A3,A4,A9,A11], whereas high-fidelity simulator-based simulations were used in three studies (12.5%) [A5,A15,A21].

(4) Outcome measurement methods

Outcome measurement methods were analyzed according to measurement instruments, assessment timing, and comparison type. Knowledge tests, competency and performance checklists, self-report questionnaires, preparedness scales, self-efficacy scales, satisfaction questionnaires, and objective structured clinical examinations were used to evaluate educational outcomes across the included studies (Supplementary Table 3). For assessment timing, pre- and post-intervention assessments were the most frequently used approach, reported in 20 studies (83.3%) [A1-3,A5-10,A12-16,A18,A19,A21-24]. Post-test-only assessments

Table 2. Components and Strategies of Simulation-Based Disaster Nursing Education

Main categories	Categories	Subcomponents	n (%)	Study no.
Program components	Educational objectives	Knowledge and theoretical understanding	17 (70.8)	A1-3,A8-10,A12,A13,A15,A16,A18-24
		Performance and technical skills	17 (70.8)	A1,A4-7,A9,A11,A13,A15-23
		Affective outcomes (self-efficacy, confidence)	14 (58.3)	A1,A3-5,A7,A13-18,A20,A21,A23
		Decision-making and critical thinking	12 (50.0)	A2,A4-12,A16,A18
		Disaster preparedness	8 (33.3)	A2,A5,A9,A14,A15,A18-20
		Learning outcomes (motivation, satisfaction, SDL)	6 (25.0)	A3,A6-8,A10,A17
		Non-technical skills (communication, teamwork)	5 (20.8)	A6,A7,A11,A12,A20
	Scenario components	Mass casualty triage	11 (45.8)	A1,A4,A5,A8,A9,A11,A12,A14,A16,A18,A24
		Disaster management phases	7 (29.2)	A2,A3,A9,A11,A16,A18,A21
		Hospital-based disaster	7 (29.2)	A7,A9,A14,A15,A19-21
		Decontamination	6 (25.0)	A14,A15,A17,A22-24
		Psychological first aid	6 (25.0)	A5-7,A12,A13,A16
	Technical components	Screen-based simulation	13 (54.2)	A2,A3,A6-8,A10-12,A18,A20,A22-24
		Game-based simulation	7 (29.2)	A2,A6-8,A10,A12,A16
		HMD-based VR	5 (20.8)	A1,A14,A17,A19,A22
		Standardized patient	5 (20.8)	A5-7,A12,A13
		Tabletop simulation	4 (16.7)	A3,A4,A9,A11
		High-fidelity simulation	3 (12.5)	A5,A15,A21
	Outcome measures	Knowledge	14 (58.3)	A3,A6-8,A10,A12,A14,A15,A18,A19,A21-24
		Self-efficacy/confidence	11 (45.8)	A1,A2,A4,A5,A7,A9,A13,A14,A17,A19,A23
		Performance/skills	11 (45.8)	A1,A9,A12,A15-17,A19-23
		Affective outcomes	10 (41.7)	A2,A3,A5-8,A10,A11,A14,A21
		Learning satisfaction	8 (33.3)	A3,A8,A10,A11,A17,A19,A22,A23
		Process outcomes (time, retention)	7 (29.2)	A1,A10,A12,A17,A20,A22,A23
		Transfer-related outcomes	5 (20.8)	A6-9,A20
Educational strategies	Strategy types	Experience-based or problem-based learning	24 (100.0)	A1-24
		Individual learning	13 (54.2)	A2,A6-8,A10,A12,A13,A17,A18,A20,A22-24
		Team-based learning	7 (29.2)	A3,A4,A9,A11,A15,A16,A21
		Mixed learning structure	4 (16.7)	A1,A5,A14,A19
	Simulation implementation	Pre-learning	20 (83.3)	A1-8,A10-18,A22-24
		Debriefing	15 (62.5)	A1,A4-9,A11-14,A16,A18,A19,A21
		Immediate feedback	13 (54.2)	A2,A6-8,A10,A14,A16,A18-20,A22-24
		Repetition	11 (45.8)	A1,A2,A8,A10,A12,A17-19,A22-24
	Learning theories	Theory applied	12 (50.0)	A1-3,A5,A6,A12,A16-18,A21,A22,A24
		Theory not applied	12 (50.0)	A4,A7-11,A13-15,A19,A20,A23

HMD = head-mounted display; SDL = self-directed learning; VR = virtual reality.

were conducted in three studies (12.5%) [A4,A17,A20], whereas one study (4.2%) used a retrospective pre-post assessment [A11]. Follow-up assessments were performed in seven studies (29.2%) [A8,A10,A12,A14,A15,A22,A24]. For comparison type, within-group pre-post and between-group comparisons were used in 20 studies (83.3%) [A1-3,A5,A7-16,A18,A19,A21-24], whereas between-group comparisons only were reported in four studies (16.7%) [A4,A6,A17,A20]. Detailed information on the measurement instruments, assessment timing, and comparison methods for each study is presented in Supplementary Table 3.

(5) Outcome measures

When educational outcomes were synthesized by outcome domain, disaster-related knowledge was the most frequently evaluated outcome, reported in 14 studies (58.3%)

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[A3,A6-8,A10,A12,A14,A15,A18,A19,A21-24]. Studies evaluating self-efficacy or confidence accounted for 11 studies (45.8%) [A1,A2,A4,A5,A7,A9,A13,A14,A17,A19,A23], and studies objectively assessing performance or technical skills also accounted for 11 studies (45.8%) [A1,A9,A12,A15-17,A19-23]. Studies assessing affective outcomes, including attitudes, beliefs, and learning motivation, accounted for 10 studies (41.7%) [A2,A3,A5-8,A10,A11,A14,A21], whereas studies evaluating learning satisfaction accounted for eight studies (33.3%) [A3,A8,A10,A11,A17,A19,A22,A23].

Seven studies (29.2%) incorporated process outcomes, such as task completion time, time required, and knowledge retention [A1,A10,A12,A17,A20,A22,A23]. Studies evaluating transfer-related outcomes, including problem-solving ability, self-leadership, and transfer of learning motivation, accounted for five studies (20.8%) [A6-9,A20].

2) Educational strategies of the programs

(1) Types of educational strategies

Educational strategies were analyzed according to learning approach, participation structure, and operational characteristics. Regarding learning approach, all studies incorporated experience-based or problem-based learning approaches [A1-24].

Regarding participation structure, individual learning accounted for the largest proportion, with 13 studies (54.2%) [A2,A6-8,A10,A12,A13,A17,A18,A20,A22-24], followed by team-based collaborative learning in seven studies (29.2%) [A3,A4,A9,A11,A15,A16,A21]. A mixed structure combining individual and team-based learning was identified in four studies (16.7%) [A1,A5,A14,A19]. Regarding operational characteristics, 23 studies (95.8%) involved instructor-designed and facilitated learning environments in which learner performance and decision-making were actively incorporated [A1-3,A5-24], whereas only one study (4.2%) used a predominantly instructor-centered approach [A4].

(2) Simulation implementation strategies

Analysis of simulation implementation strategies showed that a structured, stepwise approach incorporating pre-learning, such as prior theoretical instruction, was the most frequently applied strategy, identified in 20 studies (83.3%) [A1-8,A10-18,A22-24]. Structured debriefing was implemented in 15 studies (62.5%) [A1,A4-9,A11-14,A16,A18,A19,A21], and immediate feedback during or immediately after simulation was reported in 13 studies (54.2%) [A2,A6-8,A10,A14,A16,A18-20,A22-24]. Repetitive practice to reinforce learning was reported in 11 studies (45.8%) [A1,A2,A8,A10,A12,A17-19,A22-24].

(3) Applied learning theories

Analysis of applied learning theories showed that 12 studies (50.0%) explicitly reported using a learning theory or theoretical framework [A1-3,A5,A6,A12,A16-18,A21,A22,A24]. Experiential learning theory [A3,A5,A6] and simulation education theories, including National League for Nursing/Jeffries Simulation Theory or the Jeffries Simulation Framework [A5,A17,A22], were each used in three studies (12.5%) and were the most frequently applied frameworks. Situated Learning/Cognition Theory was identified in two studies (8.3%) [A18,A24]. Other theories, including the Health Belief Model [A2], Flow Theory [A16], Cognitive Continuum Theory [A1], Precision Teaching [A12], Behavioral Fluency Theory [A12], the Theory of Reasoned Action [A21], and Constructivist Learning Theory [A21], were each used in one study (4.2%).

3. Reported Educational Outcomes of Simulation-Based Disaster Nursing Education Programs

Various comparison conditions were used across the included studies. These included lecture-based education in eight studies (33.3%) [A1-3,A5,A8-10,A13], no intervention in three studies (12.5%) [A4,A5,A21], face-to-face simulation in three studies (12.5%) [A11,A14,A18], self-learning in two studies (8.3%) [A6,A7], web-based education in two studies (8.3%) [A23,A24], and written case-based education in two studies (8.3%) [A12,A22]. Other comparison conditions included workshop/lecture [A15], scenario-based simulation [A16], high-fidelity simulation [A17], conventional education [A19], multimedia lecture [A20], and handout [A13]. Studies using more than one comparison condition were classified into all applicable categories; therefore, study numbers may be repeated across categories.

A summary of the reported educational outcomes of the simulation-based disaster nursing education programs identified in this review is presented in Table 3.

The primary outcome measures of the programs included disaster-related knowledge, self-efficacy or confidence, performance competency or technical skills, affective outcomes, learning satisfaction, process outcomes, and transfer-related outcomes. Disaster-related knowledge significantly improved in the experimental groups in 14 studies

Table 3. Summary of Reported Educational Outcomes of Simulation-Based Disaster Nursing Education

Outcome categories	Reported educational outcomes	n (%)	Study no.
Knowledge	Increased disaster-related knowledge	14 (58.3)	A1,A2,A5-8,A10,A12-16,A18,A24
Knowledge retention	Promoted retention of knowledge over time	4 (16.7)	A8,A10,A12,A24
Self-efficacy/confidence	Increased self-efficacy and confidence in disaster response	9 (37.5)	A1,A2,A4,A5,A7,A9,A13,A14,A19
Performance competency/ technical skills	Improved triage accuracy, decontamination performance, communication, and command system performance	8 (33.3)	A1,A9,A12,A13,A15,A16,A19,A21
Affective outcomes	Improved learning motivation, engagement, and disaster preparedness beliefs	5 (20.8)	A2,A6-8,A10
Process outcomes	Reduced task completion time and improved learning retention through repeated practice	5 (20.8)	A8,A10,A12,A22,A24
Transfer-related outcomes	Reported post-learning application and change-related outcomes	5 (20.8)	A6-9,A20

(58.3%) [A1,A2,A5–A8,A10,A12–A16,A18,A24]. Four studies (16.7%) additionally reported sustained knowledge retention over time [A8,A10,A12,A24]. Self-efficacy or confidence significantly increased in the experimental groups in nine studies (37.5%) [A1,A2,A4,A5,A7,A9,A13,A14,A19], whereas two studies (8.3%) reported no significant between-group differences [A17,A23]. Performance competency or technical skills were higher in the experimental groups than in the control or comparison groups in eight studies (33.3%), including outcomes such as triage accuracy, decontamination performance, communication, and command system performance [A1,A9,A12,A13,A15,A16,A19,A21]. However, seven studies (29.2%) reported no significant between-group differences in certain outcomes, including task completion time, performance, knowledge, self-efficacy, and preparedness [A1,A14,A17,A19,A20,A22,A23]. In two studies, control groups showed better technical skill or decontamination performance outcomes [A19,A23]. Affective outcomes improved in five studies (20.8%), including learning motivation, engagement, and disaster preparedness beliefs [A2,A6-8,A10], mainly in studies applying game-based or virtual simulations. Process outcomes showed reduced task completion time or improved learning retention through repeated practice in five studies (20.8%) [A8,A10,A12,A22,A24], whereas two studies (8.3%) reported no significant between-group differences in task completion time or immediate performance accuracy [A20,A22]. Transfer-related outcomes were reported in five studies (20.8%) [A6-9,A20].

DISCUSSION

This review identified disaster-related knowledge, performance competency, mass-casualty triage scenarios, and technology-enhanced simulation as core components of simulation-based disaster nursing education. Structured instructional strategies, including pre-learning, repetitive practice, immediate feedback, and debriefing, emerged as key approaches for supporting learning. Across the included studies, improvements were most frequently reported in disaster-related knowledge, self-efficacy, performance competency, and learning motivation. Performance competency outcomes included triage accuracy, communication, decontamination performance, and command system performance, reflecting the practical competencies required for disaster response. These findings suggest that simulation-based disaster nursing education may help prepare learners for disaster response.

The educational outcomes reported across the included studies may be explained by the experiential and applied nature of simulation, which allows learners to apply knowledge and skills in realistic disaster situations while engaging in active decision-making and reflection [11,14,22]. Disaster response requires healthcare professionals to assess situations rapidly, prioritize care, allocate limited resources, and communicate effectively under uncertainty [1,14]. Simulation offers opportunities to practice these competencies in a safe learning environment while reproducing key features of real disaster situations, including time pressure, uncertainty, and resource limitations [12,16]. Consistent with these features, the included studies reported improvements not only in disaster-related knowledge and self-efficacy but also in practical disaster response competencies, including triage accuracy, communication, decontamination performance, and command system performance. The included studies also reported improvements in confidence, situational awareness, and disaster response

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competency [6,12]. However, because comparison conditions varied across studies, including lecture-based education, self-learning, web-based education, written case-based education, no intervention, and alternative simulation modalities, the reported educational effects should be interpreted with caution.

Analysis of program characteristics revealed several educational components that appear particularly relevant to disaster nursing education. Most interventions emphasized disaster-related knowledge [A1-3,A8-10,A12,A13,A15,A16,A18-24] and performance competency [A1,A4-7,A9,A11,A13,A15-23] as primary educational goals. This emphasis reflects the complexity of disaster situations, which require cognitive, technical, and collaborative competencies rather than theoretical knowledge alone [6,7]. Mass-casualty triage scenarios were frequently adopted because they require rapid prioritization and decision-making with limited resources [1]. Technology-enhanced simulation, particularly virtual reality and web-based simulation, also emerged as an important component because it enables repeated exposure to realistic disaster situations while reducing safety risks and logistical constraints [12,16]. Although these approaches may enhance learner engagement, motivation, and self-efficacy [8,17], future programs should balance technological fidelity with educational effectiveness and learner-centered design [16,17]. Moreover, many scenarios focused primarily on the response phase of disaster management. Future educational programs should therefore expand to include prevention, preparedness, and recovery phases to better reflect the full disaster management cycle.

This review also identified several instructional strategies that may contribute to learning outcomes. Experience-based and problem-based approaches were identified across the included stud ies [A1-24], reflecting the importance of critical thinking and collaborative decision-making in disaster response [14,22]. Structured learning processes incorporating pre-learning, simulation participation, immediate feedback, repetitive practice, and debriefing were also commonly implemented [11]. Among these strategies, debriefing appears particularly important because it enables learners to reflect on their actions and decision-making processes, thereby strengthening situational awareness and clinical reasoning [15]. Future disaster nursing education should also integrate individual learning with team-based collaborative learning to better reflect real-world disaster response [14,23]. Stronger theoretical integration, particularly through experiential learning theory [24] and the Jeffries Simulation Framework [25], may further improve alignment among educational objectives, instructional design, and outcome evaluation.

Several implications for future research emerged from this review. Although disaster-related knowledge was the most frequently evaluated outcome, relatively few studies examined long-term or process outcomes, such as learning retention, transfer of learning, preparedness, and team performance. Future research should therefore adopt multidimensional evaluation frameworks that assess performance competency, collaboration, preparedness, behavioral change, and sustained learning effects. In addition, disaster response is inherently collaborative and organizational rather than discipline-specific [9,14,26]. Future educational interventions should therefore move beyond single-discipline approaches and develop multidisciplinary educational models that promote interprofessional communication and team-based decision-making. Current evaluations remain largely focused on immediate educational outcomes and may not fully capture the broader effects of disaster nursing education. Assessing whether learning is retained, transferred to practice, and sustained over time may provide a more comprehensive understanding of disaster preparedness competencies. Such evidence could support the development of evidence-based educational guidelines and strengthen the practical relevance of simulation-based disaster nursing education.

This study has several limitations. Because the analysis focused on quantitative comparative studies with control groups, qualitative aspects such as learners' meaning-making processes and changes in perceptions were not fully captured. Differences in simulation types, program duration and intensity, evaluation tools, and comparison conditions may also have influenced the reported educational effects and limited direct comparisons across studies. In addition, the included studies varied in research design, outcome measures, methodological rigor, and evaluation methods, further limiting direct comparison. Because this review did not include a formal methodological quality appraisal of the included studies, the findings should be interpreted with caution. Given that disaster response is a collective and organizational process involving collaboration among diverse healthcare professionals rather than nurses alone, future research on disaster nursing simulation should move beyond single-discipline designs and expand toward multidisciplinary educational models. In particular, when learning objectives explicitly address in-

terprofessional role understanding, communication, and team-based decision-making, and when these objectives are reflected in intervention design, disaster response competencies can be evaluated at a more realistic and practice-relevant level.

CONCLUSION

This scoping review found that studies on simulation-based disaster nursing education frequently reported positive educational outcomes in disaster-related knowledge, performance competency, self-efficacy, and learning motivation. Key elements, including safe and repeated exposure to realistic disaster scenarios, structured debriefing and feedback, and scenario-centered design, were commonly reported in studies describing active learner engagement and competency development. However, most studies focused on nursing students, and evidence regarding applicability in clinical settings and long-term outcomes remains limited. Few studies examined social and organizational outcomes, such as interprofessional collaboration competencies. Future research should adopt multidisciplinary approaches involving diverse healthcare professionals and incorporate intervention designs that reflect real clinical contexts. Such efforts may support a more comprehensive understanding of the educational and practical applicability of simulation-based disaster nursing education.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - MP and JWK; data acquisition and analysis - MP and JWK; interpretation of the findings - MP and JWK; drafting and critical revision of the manuscript for important intellectual content - MP and JWK.

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DATA AVAILABILITY STATEMENT

All data extracted and analyzed in this scoping review are presented in the article and its supplementary materials.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2026.0505.

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REVIEW ARTICLE

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Nursing Competence in Recognizing and Responding to Clinical Deterioration: A Scoping Review of Components and Associated Factors

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Purpose: This scoping review identified the core components of nursing competence required for general ward nurses to recognize and manage clinical deterioration and examined how this competence has been conceptualized in previous studies. It also synthesized individual- and system-level factors associated with competence and identified research gaps relevant to nursing education, future research, and patient safety initiatives. **Methods:** This scoping review was conducted using Arksey and O'Malley's framework and reported in accordance with the PRISMA-ScR guidelines. Six databases—PubMed, CINAHL, Embase, the Cochrane Library, Scopus, and Web of Science—were searched for studies published between January 2016 and December 2025 using search terms related to clinical deterioration and nursing competence. **Results:** Twenty-one studies met the inclusion criteria. The findings were organized into two domains: nursing competencies and factors associated with competence. Technical competencies included physical assessment, vital-sign monitoring, surveillance, information analysis, and application of escalation protocols. Non-technical competencies included situational awareness, clinical decision-making, intuition, leadership, interprofessional communication, and teamwork. Individual-level factors included clinical experience, self-confidence, skill acquisition, and clinical judgment. System-level factors included education and training, relationship-building with physicians, supportive work environments, electronic tools, organizational support, and teamwork culture. **Conclusion:** Nursing competence in managing clinical deterioration is multidimensional and reflects the interaction of individual capabilities with system-level supports. Future research should develop educational strategies that strengthen both technical and non-technical skills while reinforcing organizational systems that support timely and effective responses to deterioration.

Key Words: Clinical deterioration; Clinical competence; Nurses; Patient safety

INTRODUCTION

Clinical deterioration (CD), defined as the subjective or objective manifestation of hemodynamic instability caused by declining physiological compensatory mechanisms, is a major threat to patient safety and quality of care in hospitals [1]. Despite advances in clinical monitoring technologies and rapid response systems, in-hospital CD remains a substantial patient-safety concern. In-hospital cardiac arrest, one of the most serious consequences of CD, occurs at

a reported rate of approximately 1–6 cases per 1,000 hospital admissions [2]. CD is also clinically important in general ward settings. In a cohort of 224,912 adult medical-surgical ward admissions, approximately 5% of admissions involved CD, operationally defined as unplanned transfer from the ward to the intensive care unit (ICU) or death on the ward [3]. Because physiological abnormalities often precede these events, clinicians have a critical opportunity to recognize early changes and escalate care before more severe adverse outcomes occur [3]. Early recognition of subtle physiological changes and timely intervention are therefore essential for preventing further decline and improving patient outcomes [4].

Nurses are frontline providers of patient care and play a central role in detecting early signs of deterioration through continuous observation and assessment [5]. Previous studies have identified several essential components of nursing competence in managing CD, including accurate vital-sign monitoring [6], understanding of patient conditions [7], and analysis of clinical information [8]. Communication and teamwork are also essential because timely responses to deterioration often require coordinated action across professionals [9,10].

The competence required to manage CD may differ by healthcare setting and patient acuity. In emergency departments (EDs), for example, nurses must demonstrate clinical confidence, classify patient severity, communicate effectively, and make collaborative decisions with physicians [11]. ICU nurses require advanced expertise in patient monitoring, pathophysiology, and complex communication [12]. In contrast, community healthcare settings emphasize patient assessment, screening-tool use, and adherence to clinical guidelines [13]. These differences show that competence must be tailored to patient complexity and to the clinical demands of each care environment [14,15].

Nursing competence includes both technical and non-technical skills. Technical skills involve clinical procedures and specialized knowledge, whereas non-technical skills are the "cognitive, social, and personal resource skills that complement technical skills and contribute to safe and efficient performance" [16]. Non-technical skills, including communication, situational awareness, and decision-making, help reduce errors and support patient safety, although their specific expression differs across clinical domains.

Although nurses in many clinical settings must recognize and respond to patient deterioration, general ward nurses face a distinct set of challenges. EDs and ICUs typically provide high-acuity care with continuous monitoring and immediate medical support, whereas general wards often include patients with diverse conditions whose deterioration may be subtle, gradual, and difficult to detect. In these settings, nurses are frequently the first healthcare professionals to notice early changes in a patient's condition and must decide whether to escalate care despite limited monitoring resources, competing workload demands, and variable access to rapid response systems.

Recent reviews have examined related topics, including factors influencing ward nurses' recognition of and response to patient deterioration [9], antecedents of CD in ward patients [5], ward nurses' roles in recognizing and responding to CD [17], and ward nurses' roles and responsibilities during rapid response team (RRT) activation [18]. However, these reviews have primarily addressed recognition, response, antecedents, escalation, or system activation rather than mapping the full range of competencies required to manage CD in general ward settings. In particular, previous syntheses have given limited attention to how technical skills, such as physical assessment and vital-sign monitoring, work together with non-technical skills, such as situational awareness, clinical decision-making, intuition, leadership, interprofessional communication, and teamwork. The individual- and system-level factors that shape these competencies among general ward nurses also remain insufficiently synthesized.

This scoping review examined what is known in the existing literature about nursing competence in managing CD among general ward nurses. Specifically, this study aimed to (1) identify the core components of nursing competence required to recognize and manage CD in general ward settings, (2) examine how nursing competence related to CD has been described and operationalized in previous studies, (3) explore individual- and system-level factors associated with nurses' competence in managing CD, and (4) map the characteristics of existing studies and identify gaps in the literature to inform future research, nursing education, and patient safety initiatives.

METHODS

1. Study Design

This scoping review followed the methodological framework proposed by Arksey and O'Malley [19] and further refined by Levac et al. [20]. The review question was struc-

tured using the Population-Concept-Context framework. The population was nurses; the concept was competence in managing CD, including knowledge, attitudes, technical skills, and non-technical skills such as intuition, decision-making, communication, and teamwork; and the context was general ward clinical settings. Reporting followed the PRISMA-ScR guidelines [21].

2. Inclusion and Exclusion Criteria

This review included studies that examined nursing competencies for managing CD among general ward nurses. Studies were excluded if they were (1) non–peer-reviewed publications, such as dissertations, editorials, letters, replies, conference abstracts, or review articles, because these sources generally had limited data presentation; (2) focused on pediatric or mental health deterioration; (3) conducted among nurses working in EDs, ICUs, or community settings; (4) unrelated to nursing competence in CD; or (5) published in languages other than English.

3. Search Methods

A comprehensive search was conducted in six electronic databases—PubMed, CINAHL, Embase, the Cochrane Library, Scopus, and Web of Science—to identify studies published between January 2016 and December 2025. The final search was conducted on March 10, 2026. The review protocol was not registered because protocol registration is not mandatory for scoping reviews, and no prospective registration was completed before the review began. The timeframe was selected to reflect the growing global emphasis on patient safety and the widespread implementation of rapid response systems, both of which have shaped contemporary understanding of CD in nursing practice [22,23]. The search strategy combined controlled vocabularies, including Medical Subject Headings, Emtree, and CINAHL Headings, with free-text keywords. Search terms were organized around four conceptual domains: nursing professionals (e.g., “nurses,” “nursing”), clinical situations (e.g., “clinical deterioration,” “patient deterioration”), clinical settings (e.g., “in-hospital,” “general ward”), and care escalation and competencies (e.g., “escalation,” “attitude,” “management,” “clinical competence,” “performance”). Boolean operators were used to combine search terms and refine the search strategy for each database (Supplementary Data 1). An experienced medical librarian reviewed and validated the search strategy to support methodological rigor and comprehensiveness.

4. Screening Procedure

Two reviewers independently screened titles and abstracts according to the predefined inclusion and exclusion criteria. Consistent with scoping review methodology, no formal risk-of-bias or quality assessment was undertaken because the purpose of the review was to map and synthesize existing evidence rather than evaluate intervention effectiveness [19,20]. Predefined eligibility criteria were applied throughout screening to support the selection of relevant studies. After title and abstract screening, both reviewers independently assessed the full-text articles. Discrepancies were resolved through discussion until consensus was achieved. Overall, 21 studies met the inclusion criteria and were included in the final analysis (Figure 1, Supplementary Data 2).

5. Data Extraction

Eligibility for inclusion was confirmed through a systematic and transparent selection process. Two researchers independently reviewed each study for relevance to the research question and appropriateness for inclusion, focusing on the clarity of study objectives, adequacy of data presentation, and alignment with the concept of nursing competence in managing CD. Disagreements were resolved through discussion until consensus was reached. Although formal quality appraisal or risk-of-bias assessment was not conducted because it is not required for scoping reviews, predefined inclusion and exclusion criteria were applied to improve the consistency and transparency of study selection.

Data extraction was performed by one reviewer and cross-checked by a second reviewer for accuracy and completeness. Extracted data included (1) study characteristics, such as year of publication and country; (2) methodological characteristics, such as study design and sample size; (3) nurse characteristics, such as age and work experience; (4) essential components of nursing competence in managing CD; and (5) factors associated with nursing competence.

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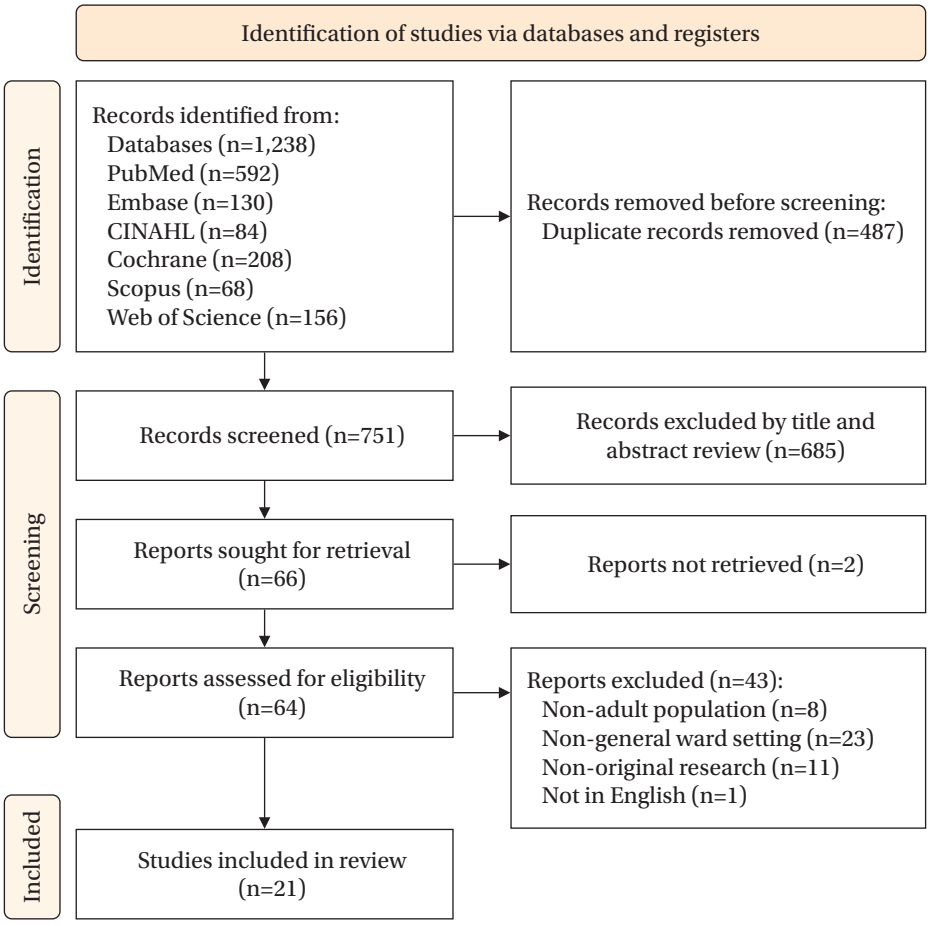

Figure 1. **Flow diagram of study selection.**

6. Data Analysis and Synthesis

A descriptive numerical and narrative synthesis was performed to summarize study characteristics and identify the essential components of and factors associated with nursing competence in managing CD. Data extraction and categorization followed a hybrid approach that combined deductive and inductive methods. First, essential components of nursing competence were deductively categorized as technical or non-technical skills based on Flin and O'Connor's conceptual framework of non-technical skills [16]. Technical skills included clinical assessment, vital-sign monitoring, surveillance, information analysis, and application of escalation protocols, whereas non-technical skills included situational awareness, clinical decision-making, intuition, leadership, interprofessional communication, and teamwork.

Inductive thematic analysis was then used to identify and categorize factors associated with nursing competence. During data extraction, one reviewer conducted initial open coding to identify factors influencing competence, and a second reviewer cross-checked the extracted data for accuracy and completeness. The two reviewers then used constant comparison across included studies to group the initial codes into broader categories. Through this process, associated factors were categorized into two overarching domains: individual-level factors and system-level factors.

Discrepancies during coding and categorization were resolved through iterative discussion until consensus was reached. When necessary, the research team reviewed and refined the initial coding framework and final categories to enhance the reliability and trustworthiness of the synthesis. Because a single study could report more than one factor associated with nursing competence, individual studies were allowed to contribute to multiple individual- or system-level categories. Therefore, the percentages represent the proportion of the 21 included studies that reported each factor.

RESULTS

Table 1 summarizes the general characteristics of the 21 included studies. Qualitative methods were used in nine studies (42.9%), descriptive designs in six studies (28.6%), quasi-experimental designs in three studies (14.3%), mixed-methods designs in two studies (9.5%), and a modified Delphi design in one study (4.8%). Sample sizes varied widely, ranging from 8 to 534 participants. The age of participating nurses was reported in 14 studies; eight studies presented mean ages, while six reported age ranges or age categories. The remaining seven studies did not report age information. Participants' work experience ranged from newly graduated nurses to those with up to 50 years of experience, although two studies did not report participants' years of experience.

Across the included studies, nursing competence in managing CD was conceptualized not simply as a set of technical skills but as a dynamic, multidimensional process. Several studies defined competence primarily as clinical judgment, emphasizing nurses' ability to recognize discordant cues, synthesize data, and navigate system vulnerabilities [A7,A16]. Other studies conceptualized competence as sequential recognition and response abilities closely linked to objective early warning scores [A4,A7,A10,A11]. A distinct subset of studies emphasized non-technical attributes, defining competence through situational awareness, experience-based intuition, and interprofessional communication [A9,A12,A15].

The operationalization and evaluation of competence varied considerably across the 21 studies, reflecting differences in study design. Nine qualitative studies explored competence through nurses' experiences and accounts of recognizing, interpreting, and responding to clinical deterioration within various clinical contexts [A2-5,A7,A9,A13,A16,A20]. Six studies using descriptive, case-based, or multisource quantitative approaches evaluated competence through various indicators related to nurses' recognition of and response to clinical deterioration, including clinical practices, perceptions, attitudes, and associated factors [A8,A12,A14,A17,A18,A21]. Three qua-

Table 1. General Characteristics of Included Studies

Author	Country	Study design	Sample size	Age (year)	Work experience (year)	Findings
				M (range) or %		
Douglas et al. [A1]	Australia	Modified Delphi study	150	37 (21 to 65)	11 (5 to 20)	Clinical assessment included airway, breathing, circulation, disability, and exposure assessments, with detailed evaluation of consciousness, skin integrity, mobility, and elimination.
Hart et al. [A2]	USA	Qualitative	28	40.0 (23 to 62)	10.5 (1 to 45)	Medical-surgical nurses identified and responded to early warning signs of deterioration, including altered levels of consciousness, changes in vital signs, and abnormal physical assessment findings. Challenges during deterioration events included room layout, lack of equipment, technology-related workflow issues, workload demands related to patient-care complexity, and lack of role clarity.
Bacon [A3]	USA	Qualitative	14	44.2 (26 to 67)	17.3 (1.5 to 45)	Nurses' responses after a failure-to-rescue surgical death may differ when no nursing error contributed to the event. Mentoring junior nurses in protective surveillance skills is essential.
Dalton et al. [A4]	UK	Qualitative	10	N/A	- (<1 to >20)	The main factors influencing nurses' assessments were collegial relationships, intuition, and interpretation of the MEWS. Nurses had no difficulty escalating care when patients had a high MEWS score but found it challenging to validate their findings and escalate care when the MEWS score was low.

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Table 1. Continued

Author	Country	Study design	Sample size	Age (year)	Work experience (year)	Findings
				M (range) or %		
Della Ratta [A5]	USA	Qualitative	11	32.8 (24 to 51)	9.4 (2 to 29)	Preceptors balanced patient-safety responsibilities with their preceptor role to support novice nurse development. Debriefing emerged as an essential tool for reviewing technical aspects of care, allowing emotional processing, and providing evaluative feedback and reassurance to novice nurses.
Duff et al. [A6]	Australia	Quasi-Experimental	60	40.7	10.4	Multimodal educational strategies, including post-program coach/educator support, helped sustain improvements in nurses' technical and non-technical skills over time.
Foley and Dowling [A7]	Ireland	Qualitative	8	N/A	5 to 22	Three themes emerged: protocol adherence versus clinical judgment, parameter adjustment and escalation, and culture. Protocol nonadherence, failure to modify parameters, and ineffective communication contributed to a task-driven approach to EWS practice.
Orique et al. [A8]	USA	Descriptive	86	37.04 (24 to 62)	7.89 (0.33 to 39)	Experience, rather than fatigue, education, or certification, helped nurses detect deterioration cues and reflected skill acquisition.
Chua et al. [A9]	Singapore	Qualitative	24	N/A	- (1 to ≥10)	Nurses reported positive effects of the daily outreach service. Escalation of care involved nurses and junior doctors navigating clinical judgment, hierarchical dynamics, and fear of criticism when deciding whether to activate the MET or call the primary team, often resulting in delayed escalation despite patient deterioration.
Peebles et al. [A10]	Australia	Quasi-Experimental	534	N/A	N/A	Just-in-time training improved escalation practices, increased nurses' confidence, and increased MET call rates.
Warren et al. [A11]	USA	Quasi-Experimental	29	- (20 to 69)	- (<1 to 25)	Simulation-based education significantly improved nurses' knowledge, confidence, and responses to deterioration. Escalation of care involved applying MEWS thresholds, promptly notifying providers, and activating rapid response to address clinical deterioration; escalation actions improved after simulation-based training.
Azimirad et al. [A12]	UK and Finland	Descriptive	179	- (18 to ≥46)	- (≤5 to ≥21)	Overall, nurses had positive attitudes toward rapid response systems. British and Finnish nurses' attitudes toward RRS activation were divided when they encountered a clinically stable patient with normal vital signs who nevertheless caused concern. The only sociodemographic factor associated with greater willingness to activate the RRS was work experience of ≥10 years.
Hession and Meaney [A13]	Ireland	Qualitative	12	- (20 to 50)	- (1 to ≥20)	Three main themes emerged: clinical support, decision-making, and knowledge sharing and communication.

(Continued on the next page)

Table 1. Continued

Author	Country	Study design	Sample size	Age (year)	Work experience (year)	Findings
				M (range) or %		
Jin et al. [A14]	Korea	Descriptive	229	27.76 (20 to 39)	N/A	Activities to improve openness, accuracy, satisfaction, and mutual understanding between physicians and nurses are needed to support patient safety.
Chua et al. [A15]	Singapore	Mixed - methods	168	- (20 to ≥50)	≤2: 17.3%, 3–5: 25.6%, 6–10: 36.9%, 11–15: 18.4%, >15: 1.8%	The automated system led nurses to monitor vital signs more cautiously, but it did not encourage comprehensive patient assessments to detect early signs of deterioration. Although nurses valued automated RRS activation as a safety net, it did not address sociocultural barriers to escalation of care.
Dresser et al. [A16]	USA	Qualitative	20	- (22 to 63)	≥3	Eight themes emerged related to noticing, interpreting, and responding to patient deterioration, along with the overarching theme of nurses' strong sense of responsibility. Nurses' clinical judgment during patient deterioration is complex and shaped by nurse, patient, and clinical-environment factors.
Al-Ghraiybah et al. [A17]	Australia	Descriptive	304	34.4 (20 to 73)	9.2 (0.02 to 50)	Each additional patient per nurse and increased missed care for patient surveillance were associated with a higher risk of 30-day inpatient mortality.
Dwyer et al. [A18]	Australia	Descriptive	291	N/A	≥10: 42%	Nurses reported high levels of previous compliance and strong intentions to continue complying. The proposed conceptual model indicated that clinical judgment, education, interprofessional trust, workplace norms, and cultural factors directly or indirectly influence nurses' intention to comply with EWS protocols.
Mbuthia et al. [A19]	Kenya	Mixed - methods	405	N/A	- (<1 to ≥30)	Less than 2% of the reviewed patient records had complete documentation of all six vital signs during the 24 hours before death. Five interrelated factors hindered nurses' ability to detect and respond to clinical deterioration: insufficient vital-sign monitoring, limited equipment and supplies, poor staffing and high workload, lack of training and guidelines, and communication and teamwork constraints.
Ruiz et al. [A20]	USA	Qualitative	24	N/A	- (2 to 30)	Five key themes were identified: recognizing deterioration, deciding to escalate, team responsiveness, communication during escalation, and perceived effectiveness.
Chipeta et al. [A21]	Malawi	Descriptive	322	20–29: 51.7%, 30–39: 43.9%, ≥40: 4.3%	<1: 22.4%, 1–2: 43.8%, 3–4: 25.8%, 5: 8.1%	Nurses with more experience, ICU backgrounds, or prior experience discussing deterioration were significantly less likely to struggle with escalation decisions.

EWS = early warning system; ICU = intensive care unit; M = mean; MET = medical emergency team; MEWS = modified early warning score; N/A = not available; RRS = rapid response system.

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si-experimental studies operationalized competence by examining changes in knowledge, confidence, clinical performance, or rapid response system activation following simulation-based education or just-in-time training interventions [A6,A10,A11]. Two mixed-methods studies combined quantitative indicators with qualitative accounts to provide a comprehensive understanding of nurses' competence in managing clinical deterioration [A15,A19]. One modified Delphi study operationalized competence by establishing expert consensus on its essential domains and indicators through an iterative process [A1].

1. Essential Components of Nursing Competence in Managing CD

The included studies identified 11 essential components of nursing competence related to CD management (Table 2). Vital-sign monitoring was identified in 13 studies (61.9%), physical assessment in 12 studies (57.1%), escalation-protocol application in 10 studies (47.6%), interprofessional communication and collaborative teamwork in nine studies each (42.9%), information analysis in eight studies (38.1%), clinical decision-making and surveillance in seven studies each (33.3%), clinical intuition in five studies (23.8%), and situational awareness and leadership in two studies each (9.5%). These components indicate that competence in managing CD extends across the full deterioration-management process, from recognizing early changes to interpreting clinical information and initiating an appropriate response.

The 11 core components were organized into a conceptual framework with three sequential but interconnected phases, with collaborative coordination spanning all phases. First, the detection and information-gathering phase involved surveillance, vital-sign monitoring, and physical assessment to identify early physiological changes. Second, the cognitive processing and synthesis phase involved information analysis and intuition, which supported interpretation of clinical cues and contributed to situational awareness and decision-making. Third, the action and escalation phase involved escalation-protocol application and leadership to facilitate timely responses to deterioration. Across all three phases, collaborative coordination, comprising interprofessional communication and collaborative teamwork, supported integration of the overall deterioration-management process. This synthesized framework shows how assessment and information gathering are linked with cognitive processing, clinical action, and collaborative coordination in CD management (Figure 2).

Table 2. Essential Components of Nursing Competence in Managing Clinical Deterioration

Authors	Physical assessment	Vital signs	Information analysis	Surveillance	Escalation protocol	Situational awareness	Decision-making	Intuition	Leadership	Interprofessional communication	Collaborative teamwork
Douglas et al. [A1]	✓			✓							
Hart et al. [A2]	✓	✓			✓			✓		✓	✓
Bacon [A3]	✓	✓		✓						✓	
Dalton et al. [A4]	✓	✓	✓		✓			✓			✓
Della Ratta [A5]							✓	✓			
Duff et al. [A6]	✓	✓				✓			✓	✓	
Foley and Dowling [A7]			✓		✓		✓			✓	✓
Orique et al. [A8]	✓	✓		✓		✓					
Chua et al. [A9]	✓	✓	✓		✓		✓				✓
Peebles et al. [A10]	✓	✓								✓	
Warren et al. [A11]		✓			✓						
Azimirad et al. [A12]		✓			✓		✓	✓			
Hession and Meaney [A13]							✓			✓	✓
Jin et al. [A14]										✓	✓
Chua et al. [A15]	✓	✓	✓		✓						
Dresser et al. [A16]	✓	✓	✓	✓	✓						✓
Al-Ghraiybah et al. [A17]				✓							
Dwyer et al. [A18]					✓		✓				✓
Mbuthia et al. [A19]	✓	✓	✓	✓	✓						
Ruiz et al. [A20]			✓					✓	✓	✓	✓
Chipeta et al. [A21]	✓	✓	✓	✓			✓			✓	
Total, n (%)	12 (57.1)	13 (61.9)	8 (38.1)	7 (33.3)	10 (47.6)	2 (9.5)	7 (33.3)	5 (23.8)	2 (9.5)	9 (42.9)	9 (42.9)

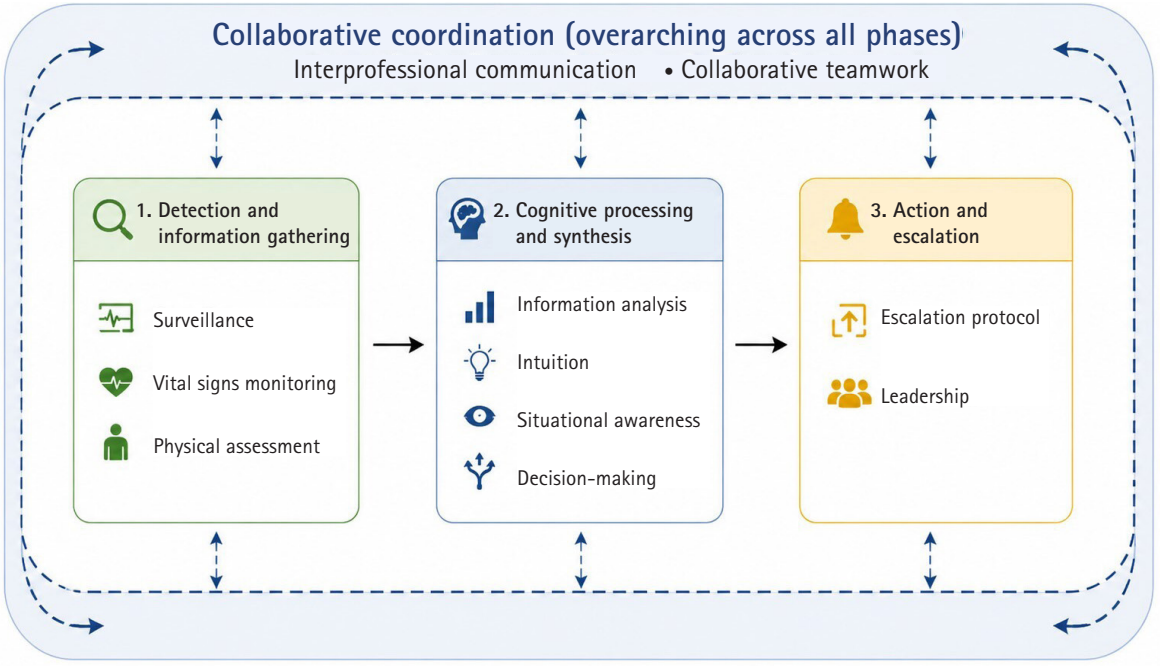

Figure 2. Conceptual framework of nursing competence in managing clinical deterioration.

2. Factors Associated with Nursing Competence in Managing CD

Factors associated with nursing competence were classified into individual- and system-level domains (Table 3). At the individual level, prior experience was the most frequently identified factor (9 studies, 42.9%), including experience in acute care, managing patient deterioration, serving as a preceptor, and activating rapid response systems [A2-5,A7-10,A16]. Other individual-level factors included self-confidence [A12,A15,A18,A21], skill acquisition [A4], and clinical judgment [A16].

At the system level, education and training emerged as the most frequently reported factor (8 studies, 38.1%) [A1,A6,A10, A12,A14,A18-20], underscoring the importance of continuous, context-specific learning opportunities. Other system-level factors included relationship-building with physicians [A9,A13,A14,A16], work environment [A2,A3,A6, A12,A16,A18,A19], technological support, such as electronic monitoring tools and data systems [A7,A10,A11,A13, A17,A19], organizational support systems, such as rapid response teams [A15,A18,A20], and teamwork culture [A17,A18,A21].

DISCUSSION

The findings of this review are consistent with previous research [6,9,17], indicating that vital-sign monitoring, physical assessment, data interpretation, clinical decision-making, and adherence to escalation protocols are essential competencies for nurses across diverse clinical settings. For contextual comparison, similar competence domains have been reported in external literature on nurses working in EDs [11,24,25], ICUs [12], and community healthcare environments [13], although these settings were excluded from the present scoping review. These core elements represent fundamental clinical abilities needed for effective patient monitoring and timely intervention. The present findings also reaffirm that situational awareness, clinical judgment, and interprofessional communication are broadly relevant capabilities for recognizing and managing patient deterioration promptly and appropriately.

The application of nursing competence in responding to CD differs by clinical setting. In general wards, where patient decline is often subtle and gradual, nurses rely heavily on continuous observation, vigilance, and experience-based intuition, particularly when continuous monitoring or immediate system support is unavailable [A4,A12,26,27]. In contrast, ED nurses work in high-acuity, fast-paced environments that require rapid triage, clear role delineation, and structured communication to manage unpredictable deterioration [11,24]. Similarly, in ICUs, where patients are critically ill, clinically complex, and at high risk of instability, nursing competence emphasizes

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Table 3. Factors Associated with Nursing Competence in Managing Clinical Deterioration

Level	Factor	Studies	n (%)
Individual	Prior experience: acute care, deterioration events, preceptorship, and RRS activation	[A2-5,A7-10,A16]	9 (42.9)
	Self-confidence	[A12,A15,A18,A21]	4 (19.0)
	Level of skill acquisition	[A4]	1 (4.8)
	Effective clinical judgment	[A16]	1 (4.8)
System	Relationship-building with physicians	[A9,A13,A14,A16]	4 (19.0)
	Education and training: basic, advanced, decision-making, and intuition-support training	[A1,A6,A10,A12,A14,A18-20]	8 (38.1)
	Work environment: staffing adequacy, workload, role clarity, and protocol adherence	[A2,A3,A6,A12,A16,A18,A19]	7 (33.3)
	Electronic tools and technology	[A7,A10,A11,A13,A17,A19]	6 (28.6)
	Support systems, including RRTs	[A15,A18,A20]	3 (14.3)
	Teamwork culture	[A17,A18,A21]	3 (14.3)

Percentages were calculated based on the total number of included studies (N=21). Because a single study could report multiple factors across different categories, the sum of the percentages exceeds 100%.
RRS=rapid response system; RRT=rapid response team.

sustained surveillance, advanced technical interventions, and multidisciplinary teamwork supported by standardized protocols and monitoring technologies [12,28].

In community care, nurses manage deterioration in contexts characterized by chronic illness, frailty, and limited resources, requiring holistic assessment, autonomous decision-making, and interprofessional coordination to support safe, patient-centered care [13,27]. Compared with the resource-rich and highly structured environments of ICUs and EDs, general ward settings involve high patient loads and complex escalation pathways. This contrast highlights the contribution of the present review: early recognition and decision-making in general wards require context-specific competencies rather than reliance on technological alerts alone.

Despite these contextual differences, early recognition, timely intervention, and effective communication remain essential across settings, although their expression varies by patient acuity, available resources, and organizational structure. These findings support competence-development strategies that are aligned with the realities of each care environment. For general ward nurses, educational initiatives should emphasize recognition of subtle and progressive deterioration [A2,A6] through experiential learning strategies, including simulation-based education, case-based training, and reflective practice [26,29]. Training programs should therefore move beyond acute emergency scenarios alone and include simulations of gradual deterioration, structured debriefings, and exercises in decision-making under uncertainty to strengthen situational awareness and clinical reasoning. Embedding these competencies into pre-licensure curricula, continuing professional education, and interprofessional training may improve nurses' preparedness for real-world ward-based deterioration events.

At the individual level, clinical experience was a key factor, particularly in the development of complex cognitive competencies such as intuition. To understand this relationship, intuition should be distinguished from clinical reasoning and clinical judgment. Clinical reasoning refers to the analytical, stepwise cognitive process of gathering objective data, synthesizing information, and formulating a hypothesis [30]. Clinical judgment is the actionable conclusion derived from this reasoning process [31]. In contrast, intuition operates as a rapid, non-analytical synthesis of subtle and often unquantifiable cues that develops through extensive clinical experience. Rather than replacing objective assessment, intuition may function as an early tacit signal—a sense that "something is wrong"—that prompts nurses to initiate formal clinical reasoning and apply clinical judgment before physiological parameters exceed predefined warning thresholds [32].

Repeated exposure to deterioration events and emergency situations may improve nurses' ability to recognize subtle, recurring patterns of patient decline. Through accumulated clinical experience, these pattern-recognition processes may contribute to intuition, which can serve as an early cue for clinical reasoning and support timely clinical judgment before overt physiological deterioration becomes evident [29,33,34]. Experienced nurses also often

serve as mentors, helping novice staff develop competence through role modeling and feedback [26]. At the system level, educational infrastructure, escalation protocols, teamwork, and staffing conditions influenced nurses' ability to respond effectively. Supportive work environments with clear procedures and sufficient resources facilitated timely action, whereas communication barriers and staff shortages hindered effective responses [10,35].

Compared with previous studies focused primarily on emergency and intensive care contexts, this review highlights the distinct challenges of general ward settings, where system resources are often limited and escalation processes may be inconsistently applied [36]. The findings suggest that interventions should strengthen individual competence through experiential learning while also reinforcing system-level supports tailored to ward environments. Such combined strategies may improve early recognition, timely intervention, and patient safety. Recent evidence indicates that organizational culture, role ambiguity, and insufficient empowerment continue to impede ward nurses' escalation of care [A2,A17,A20], underscoring the need for institutional policies that clearly define and integrate ward nurses' roles within RRT frameworks [18].

This scoping review has several limitations. First, formal methodological quality appraisal and risk-of-bias assessment were not conducted. Although such evaluations are not mandatory for scoping reviews, the heterogeneity of study designs, sample sizes, and clinical contexts may have introduced varying degrees of bias and may limit the strength of conclusions that can be drawn from the synthesized evidence. Second, the search strategy had several restrictions. The review was limited to peer-reviewed English-language studies published from January 2016 to December 2025 and excluded non-English studies and gray literature. Although this timeframe was selected to reflect contemporary clinical practice shaped by patient safety initiatives, rapid response systems, early warning systems, and escalation protocols, excluding studies published before 2016 may have limited the review's ability to capture earlier conceptual development of nursing competence related to CD. In addition, although the search terms were designed to identify studies on CD and nursing competence, related concepts used in adjacent clinical fields, such as failure to rescue, rapid response system activation, escalation of care, clinical judgment, and patient surveillance, may not have been fully captured. Relevant studies using different terminology may therefore have been missed. The absence of supplementary hand-searching or reference-list screening may also have led to omission of potentially relevant literature not indexed in the selected electronic databases. Third, although systematic data extraction and synthesis procedures were used, qualitative categorization of competency components and associated factors may have involved some subjectivity. To reduce this limitation, extracted data and categories were cross-checked by the reviewers and refined through discussion. Finally, the operational definition of general ward nursing may not fully capture variation across healthcare systems, including differences in staffing models, nurse-to-patient ratios, monitoring resources, and escalation protocols, which may limit the generalizability of the findings.

This review also has several strengths. By focusing exclusively on general ward nursing, an area often underrepresented in deterioration-related literature, it clarifies the challenges nurses face when detecting and responding to early, subtle signs of patient decline. The review also provides a preliminary map of nursing competence in this context by synthesizing both individual- and system-level factors and describing how contextual conditions shape nurses' performance. By incorporating qualitative and mixed-methods studies, the synthesis captures experiential insights that are often missed in purely quantitative analyses and provides a foundation for future empirical research.

Educational interventions should move beyond acute emergency scenarios alone and place greater emphasis on recognizing subtle, progressive deterioration, using intuition appropriately, and making clinical decisions under uncertainty. Interprofessional debriefings and role-clarification exercises may reduce role conflict and build nurses' confidence within RRT systems [18]. Competency development should also be treated as a continuum, beginning with multi-stage integrated simulation curricula for third- and fourth-year pre-licensure students and continuing with experience-tailored training for practicing ward nurses.

Effective educational strategies should move beyond lecture-only approaches and incorporate experiential learning. Recommended delivery methods include mixed reality, high-fidelity simulations of subtle ward deterioration, case-based reflection, and interprofessional debriefings. These programs should be evaluated using standardized metrics that assess both objective performance and self-efficacy, such as the Perceived Self-Efficacy in Nursing Com-

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petencies Scale [37]. Education also requires system-level reinforcement; healthcare organizations should implement clear escalation protocols and early warning systems and foster a nonpunitive culture to reduce escalation hesitancy among ward nurses [38]. Notably, although not included among the 21 studies reviewed, Xu et al. [8] developed and validated a structured instrument, the Recognition and Response to Clinical Deterioration (RRCD), to systematically measure junior nurses' recognition and response abilities to clinical deterioration. This instrument provides an important foundation for the standardized assessment of deterioration-related nursing competence. Future research should develop and validate standardized instruments for measuring context-specific competencies, including intuition and deterioration-related decision-making, particularly within the Korean healthcare context. Such tools will be important for advancing empirical research and improving education and policy frameworks aimed at strengthening nurses' competence in managing CD.

Future research should investigate the developmental trajectory of intuition using established theoretical frameworks, such as Benner's Novice to Expert theory [39] and Tanner's Clinical Judgment Model [40]. Such theory-informed studies may clarify how repeated clinical exposure, reflective learning, and progressive expertise contribute to intuitive recognition, clinical judgment, and timely responses to patient deterioration.

CONCLUSION

This scoping review identified key components of and factors associated with nursing competence in managing CD in general wards. Core competencies such as vital-sign monitoring, assessment, clinical reasoning, and escalation are broadly relevant across settings, but their application is shaped by ward-specific challenges, including subtle symptom progression and limited monitoring support. Competence development should address both technical proficiency and non-technical abilities, including situational awareness, intuition, and decision-making under uncertainty. Individual competence may be strengthened through simulation-based training and mentorship, whereas system-level improvement requires supportive teamwork cultures and simplified escalation pathways.

To address existing research gaps, future studies should move beyond descriptive designs and focus on actionable priorities. First, ward-specific measurement tools should be developed and validated to assess non-technical competencies, such as intuitive decision-making and situational awareness, with adequate reliability and validity. Second, future research should evaluate the effects of organizational-level interventions, such as integrated early warning systems, structured interprofessional debriefings, and revised escalation protocols, on nurses' behavioral responses and patient safety outcomes. Finally, longitudinal studies are warranted to examine how continuous competency-based education and accumulated clinical experience interact to sustain deterioration-management skills over time.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - URS; data collection - URS; analysis - URS and YJ; interpretation of the data - URS and YJ; and drafting or critical revision of the manuscript for important intellectual content - URS and YJ.

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DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding author.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2026.0514.

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Development and Validation of BE-ALERT as an Early Stroke Detection Application

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Purpose: Stroke is a leading cause of morbidity and mortality worldwide, and rapid early detection is essential. Although screening tools such as FAST (face, arm, speech, and time) are widely used, they may miss posterior strokes, whereas BE-FAST (balance-eyes, face, arm, speech, and time) demonstrates greater sensitivity. However, its implementation in digital formats remains limited. This study aimed to develop, validate, and implement BE-ALERT (balance-eyes-arm weakness-language difficulties-extreme headache-reaction slowed or confusion-time to response) as a community-based early stroke detection application. **Methods:** This research and development study consisted of development, validation, diagnostic accuracy testing, and community implementation. The development and validation phase included 160 family caregivers of patients with stroke who were aged ≥18 years. The diagnostic accuracy phase included 500 family caregivers who accompanied consecutive patients with suspected stroke in the emergency department. Family caregivers completed the BE-ALERT assessment while accompanying the patients, and their assessment results were compared with neurologist-confirmed diagnoses. **Results:** Validation showed a content validity index of 0.95 and a Cronbach α reliability coefficient of .82. Community implementation among 160 participants was associated with higher stroke knowledge scores (82.1) and stronger intention to seek immediate treatment (4.5). Receiver operating characteristic curve analysis yielded an area under the curve of 0.836, indicating good diagnostic accuracy. BE-ALERT showed a sensitivity of 85.0%, specificity of 82.1%, negative predictive value of 94.5% and System Usability Scale score of 74. **Conclusion:** BE-ALERT is a practical, accurate, and well-accepted tool for community-based early stroke detection. It may support stroke screening, public education, and timely treatment-seeking behavior.

Key Words: Stroke; Early diagnosis; Mobile applications; Mass screening; Sensitivity and specificity

INTRODUCTION

Stroke occurs when cerebral blood flow is interrupted, resulting in a serious medical condition that requires immediate treatment [1]. It is a leading cause of death and disability in adults and is one of the most common reasons for emergency department visits [2]. Prompt treatment is essential to reduce the risk of severe brain injury and improve functional recovery [3]. Stroke can result in long-term sequelae and increase the risk of recurrence, making early detection critically important. Family members play an essential role in recognizing symptoms and detecting recurrence [4]. A recent multicenter study reported a 1-year stroke recurrence rate of 9.96%, with a combined death or recurrence rate of 21.83% during the same period, underscoring the importance of early detection of post-stroke complications [5]. Earlier medical intervention is associated with reduced brain injury; however, many families continue to struggle to recognize stroke symptoms and respond appropriately [4]. Family-based educational interventions have been associated with improved ability to detect recurrence symptoms and provide recovery support [6].

Early stroke detection can be performed using various screening tools, including the Cincinnati Prehospital Stroke Scale, FAST (face, arm, speech, and time), Los Angeles Prehospital Stroke Screen, Melbourne Ambulance Stroke Screen, Medic Prehospital Assessment for Code Stroke, and Recognition of Stroke in the Emergency Room. These instruments are structured and designed for ease of use [7]. The BE-FAST (balance-eyes, face, arm, speech, and time) method allows individuals to self-screen for stroke symptoms. However, effective early detection also depends on healthcare system responsiveness and family caregiving capacity [8]. Limited public knowledge regarding early detection tools and technologies remains a significant barrier to optimal stroke prevention and treatment [9].

Globally, stroke is the second leading cause of death and the third leading cause of disability [10]. According to the World Health Organization, more than 12 million new stroke cases occur annually [11]. In Indonesia, the prevalence of stroke is approximately 8.3 per 1,000 population (0.83%) [12]. Delays in recognizing early stroke symptoms frequently result in patients missing the therapeutic "golden period" for reperfusion therapy. FAST and BE-FAST have reported sensitivities of approximately 77% [13]; however, stroke assessment instruments vary in complexity and length, making it challenging to determine the most appropriate tool during emergencies [2].

Commonly used screening tools for stroke detection include FAST and BE-FAST. FAST can support early stroke identification at the emergency medical services (EMS) call-taker level, with an acceptable sensitivity of 87.5% for stroke cases subsequently diagnosed by EMS. However, its specificity (17.4%), positive predictive value (PPV) (34.0%), and overall accuracy (40.4%) are low, indicating that FAST is more appropriate as a screening tool to trigger early suspicion and timely resource allocation than as a stand-alone diagnostic tool [14]. FAST may expedite triage and follow-up when used by EMS call-takers, but definitive diagnosis requires additional examinations by trained medical personnel. Prior studies have recommended improving public and call-taker knowledge of stroke risk factors and symptoms and further evaluating the influence of social and educational variables on FAST screening performance [15].

BE-FAST is a highly sensitive screening tool for detecting acute ischemic stroke in hospitalized patients, including those meeting criteria for reperfusion therapy; however, specificity is moderate, and false positives among non-cerebrovascular conditions may occur [16]. Although BE-FAST sensitivity among hospitalized patients is slightly lower than among patients presenting from the community (85% vs. 94%), it retains clinical value, particularly when the patient has an intact level of consciousness [17].

BE-ALERT (balance-eyes-arm weakness-language difficulties-extreme headache-reaction slowed or confusion-time to response) was developed from existing screening tools (FAST and BE-FAST) for use in the community via a web-based application. In Indonesia, prehospital delays are common; contributing factors include limited awareness of stroke symptoms, cultural beliefs, low socioeconomic status, and poor transportation access, which may result in arrival after the 3.0- to 4.5-hour therapeutic window from symptom onset. The application uses plain language and was tested for validity and reliability. In addition, it provides guidance on accessing healthcare facilities during an event and instructions for home management. Because the success of stroke therapy depends strongly on rapid hospital arrival—and delays in symptom recognition remain common—the design, validation, and implementation of BE-ALERT as an early stroke detection tool are expected to support community-based stroke screening and education.

METHODS

1. Study Design

This study used a research and development (R&D) design with a descriptive quantitative approach to evaluate whether the developed application was valid, reliable, practical, and suitable for use. The study is reported in accordance with the Standards for Reporting Diagnostic Accuracy Studies (STARD) guidelines.

2. Setting and Samples

Participants in phase 1 were family caregivers of patients with stroke who provided care in the home, inpatient ward, or emergency department of a government hospital in Central Java, Indonesia, between February and March 2025. Caregivers were eligible if they were aged ≥18 years, lived in the same household as the patient, owned an Android or iOS smartphone, and were willing to participate. Those with cognitive or communication impairments that could interfere with study participation were excluded. Consecutive sampling was used to recruit 160 family caregivers. This phase assessed caregivers' knowledge of early stroke symptom recognition and examined whether knowledge differed by age, sex, and educational level. The findings were used to identify educational needs and guide development of the BE-ALERT application. The minimum required sample size for phase 1 was estimated using G*Power version 3.1.9 for an F-test (linear multiple regression, fixed model, R^2 deviation from zero) with one predictor (total BE-ALERT score). Assuming a medium effect size ($f^2 = 0.15$), $\alpha = .05$, and statistical power $(1-\beta)$ of .95, the minimum required sample size was approximately 90 participants. To improve statistical precision and account for potential missing data, 160 participants were included.

The expert panel comprised six purposively selected specialists: two neurologists, two nursing experts with experience in stroke management, and two health information technology experts. The panel conducted content validation of the BE-ALERT application during the development phase.

Phase 2 consisted of diagnostic accuracy testing of the completed BE-ALERT application and was conducted from April to July 2025. During this predefined recruitment period, 500 family caregivers accompanying 500 consecutive patients with suspected stroke who presented to the Emergency Department of K.R.M.T. Wongsonegoro Regional Hospital, Semarang, Indonesia, were recruited using consecutive sampling. All eligible caregiver-patient pairs presenting during the study period were invited to participate, yielding a final sample of 500 pairs. The phase 2 sample size was determined by the number of eligible consecutive caregiver–patient pairs recruited during the predefined study period. The sample included both stroke-positive and stroke-negative cases, allowing sensitivity, specificity, and other diagnostic accuracy measures to be estimated with 95% confidence intervals.

Eligible participants were family caregivers aged ≥18 years who lived in the same household as the patient and accompanied the patient to the emergency department. Caregivers completed the BE-ALERT assessment on their smartphones while awaiting the patient's clinical evaluation. The neurologist-confirmed diagnosis, established through neurological examination and appropriate diagnostic investigations, served as the reference standard for diagnostic performance. If caregivers had difficulty accessing or completing the application, trained emergency department nurses, the principal investigator, and research assistants who had received standardized training provided technical assistance; however, caregivers entered all responses directly. The content, scoring algorithm, and assessment results of BE-ALERT were not disclosed to the treating neurologists and were not incorporated into routine clinical assessment or decision-making. Emergency department nurses recorded the neurologist-confirmed diagnosis and supporting examination results on study record forms for research purposes. The research team then used these records as the reference standard for diagnostic accuracy analysis.

3. Measurements/Instruments

The BE-ALERT application was developed based on the BE-FAST framework and incorporates a rapid-action messaging feature. The reference standard for stroke diagnosis was the neurologist-confirmed diagnosis. Application usability was assessed with the System Usability Scale (SUS). BE-ALERT is a family-based observational screening tool designed to help caregivers recognize early stroke symptoms by directly observing patients with suspected stroke. The application includes seven assessment components: balance, eyes, arm weakness, language difficulties, extreme headache, reaction slowed or confusion, and time to re-

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sponse. Detailed scoring criteria for each BE-ALERT component are presented in Supplementary Data 1. Six components are scored on a four-point scale (1–4), whereas the time to response component is scored on a two-point scale (1–2). Higher scores indicate greater impairment or delayed response, yielding a total possible BE-ALERT score ranging from 7 to 26. For the diagnostic accuracy analysis, participants with a total BE-ALERT score >7 were classified as BE-ALERT positive, indicating possible stroke risk, whereas those with a total score ≤7 were classified as BE-ALERT negative. When the total score exceeded 7, the application displayed the message, "High risk, go to the hospital immediately," advising users to seek immediate medical evaluation. When the total score was ≤7, the application displayed the message, "No signs of stroke found at this time," while recommending further medical evaluation if symptoms persisted or worsened. This predefined threshold was used to compare the BE-ALERT assessment as the index test with the neurologist-confirmed diagnosis as the reference standard.

4. Data Collection/Procedure

This study employed a modified Borg and Gall R&D framework consisting of seven sequential stages: (1) needs identification, (2) application design and development, (3) content validation, (4) reliability and construct testing, (5) implementation testing, (6) diagnostic accuracy testing, and (7) revision and finalization.

The first stage involved identifying users' needs through a literature review, focus group discussions, and surveys of family caregivers of patients with stroke. These findings were used to develop assessment domains and items based on the BE-FAST framework and to design the initial BE-ALERT prototype. Content validity was then evaluated by an expert panel using the content validity index (CVI), including the item-level content validity index (I-CVI ≥0.78) and scale-level content validity index/average (S-CVI/Ave ≥0.90). Reliability and construct testing were conducted among 160 family caregivers using Cronbach α and the Kuder-Richardson Formula 20 (KR-20), with values ≥.70 considered acceptable.

After reliability testing, implementation testing was conducted through community education sessions using BE-ALERT. Changes in participants' knowledge and intention to respond to stroke symptoms were evaluated with the Wilcoxon signed-rank test ($p<.05$), and application usability was assessed with the SUS, with a score ≥68 indicating acceptable usability. Findings from these stages were used to refine the application before diagnostic accuracy evaluation.

A separate diagnostic accuracy study was then conducted to evaluate the finalized BE-ALERT application against a clinical reference standard. Family caregivers accompanying consecutive patients with suspected stroke completed the BE-ALERT web-based assessment on their smartphones while awaiting the patient's clinical evaluation in the emergency department. If caregivers required assistance accessing or completing the application, trained emergency department nurses, the principal investigator, and research assistants who had received standardized training provided technical support; however, caregivers entered all responses directly.

Before data collection began, the research team informed the physician responsible for the emergency department that a diagnostic accuracy study would be conducted as part of the institutional research approval process. However, the content, scoring algorithm, and assessment results of BE-ALERT were not disclosed to the treating neurologists and were not incorporated into routine clinical assessment or decision-making. The reference-standard diagnosis was established independently according to routine hospital practice through neurological examination and supporting diagnostic investigations performed by the treating neurologist. Emergency department nurses then documented the neurologist-confirmed diagnosis and supporting examination results in the study data collection forms, which the research team used as the reference standard for diagnostic accuracy analysis. The BE-ALERT assessment was completed before the final clinical diagnosis was established, and both the index test and reference-standard diagnosis were completed during the same emergency department visit.

The diagnostic performance of the BE-ALERT application was evaluated using receiver operating characteristic (ROC) curve analysis by comparing the BE-ALERT assessment as the index test with the neurologist-confirmed diagnosis as the reference standard. Sensitivity, specificity, PPV, negative predictive value (NPV), and the area under the ROC curve (AUC) were calculated with corresponding 95% confidence intervals. The final stage involved revising BE-ALERT on the basis of findings from content validation, reliability testing, diagnostic accuracy evaluation, and implementation testing. Revisions focused on the application

interface, assessment workflow, wording, navigation, and user guidance, in accordance with expert recommendations and user feedback. After these revisions were incorporated, the final version of BE-ALERT and its accompanying user guide were finalized for community and clinical use.

5. Ethical Considerations

Written informed consent was obtained from all participants. The study approval was obtained from K.R.M.T. Wongsonegoro Regional Hospital, Semarang City (No. 033/Kom.EtikRSWN/II/2025).

6. Data Analysis

Validation analyses included content validity assessment with the CVI and reliability testing with KR-20. Internal consistency was evaluated using Cronbach α, with values ≥.70 considered acceptable. Diagnostic accuracy was evaluated by comparing the BE-ALERT assessment as the index test with the neurologist-confirmed diagnosis as the reference standard, which was established through routine neurological examination and supporting diagnostic investigations according to hospital practice. Diagnostic performance was assessed by calculating sensitivity, specificity, PPV, NPV, ROC curve analysis, and AUC. Sensitivity, specificity, PPV, NPV, and AUC were reported with corresponding 95% confidence intervals (CIs), with CIs for diagnostic accuracy measures estimated using the Wilson method. Implementation testing compared preintervention and postintervention knowledge and intention-to-act scores using the Wilcoxon signed-rank test ($p < .05$). Application usability was summarized with the SUS. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA).

RESULTS

1. Participants

A total of 160 family caregivers of patients with stroke participated in the needs assessment phase. For knowledge of stroke symptoms, 45 participants (28.1%) had poor knowledge, 59 (36.9%) had adequate knowledge, and 56 (35.0%) had good knowledge. The most frequently requested BE-ALERT feature was risk logging (53 participants, 33.1%), followed by educational videos (50 participants, 31.3%), easy access (30 participants, 18.8%), and emergency alerts (27 participants, 16.9%).

Knowledge scores differed significantly according to age group. Young adults had significantly lower knowledge scores than adults (59.46 ± 12.35 vs. 74.83 ± 14.27, t = –3.76, $p < .001$). No significant difference in knowledge scores was observed according to sex, with mean scores of 74.75 ± 15.60 among males and 72.49 ± 13.83 among females (t = 0.97, $p = .333$). Knowledge scores also differed significantly according to educational level (F = 5.89, $p < .001$). Participants with primary education had the highest mean knowledge score (79.83 ± 13.66), followed by those with further education (71.98 ± 13.20), no schooling (71.81 ± 15.13), and higher education (67.13 ± 14.55) (Table 1).

2. Needs Identification in the Development of the BE-ALERT Early Stroke Detection Application

The needs assessment informed the development of BE-ALERT. Participants most frequently requested risk logging, educational videos, easy access, and emergency alert features, and these preferences were incorporated into the application design (Table 1).

3. Components of BE-ALERT

1) Development domain

The development of the BE-ALERT domain components is presented in Table 2.

2) BE-ALERT application prototype

Based on the domain results described above, a prototype BE-ALERT application was developed with the following main features.

(1) Main page

The “Early Detection” button directs users to the BE-ALERT form. The “Stroke Education” button provides short videos, infographics, and articles. The “History & Risk Factors” button allows users to record blood pressure, blood glucose, history of hypertension/diabetes, and smoking habits. The “Emergency” button allows users to call the emergency service number (119) with one click.

(2) The early detection form (BE-ALERT)

A structured questionnaire with component-specific re-

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Table 1. General Characteristics and Needs Assessment of Participants (N=160)

Indicators	Categories	n (%)	Knowledge M±SD	t or F (p)
Aspects assessed	Public knowledge about stroke symptoms			
	Poor	45 (28.1)	-	-
	Adequate	59 (36.9)	-	-
	Good	56 (35.0)	-	-
	Requirements for digital application features			
	Easy to access	30 (18.8)	-	-
	Emergency alerts	27 (16.9)	-	-
	Educational videos	50 (31.3)	-	-
	Risk logging	53 (33.1)	-	-
Characteristics	Age			–3.76 (<.001)
	Young adults	13 (8.1)	59.46±12.35	
	Adults	147 (91.9)	74.83±14.27	
	Sex			0.97 (.333)
	Male	77 (48.1)	74.75±15.60	
	Female	83 (51.9)	72.49±13.83	
	Education			5.89 (<.001)
	No schooling	37 (23.1)	71.81±15.13	
	Primary education	52 (32.5)	79.83±13.66	
	Further education	41 (25.6)	71.98±13.20	
	Higher education	30 (18.8)	67.13±14.55	

M=mean; SD=standard deviation.

Table 2. BE-ALERT Content Validity Test Results

BE-ALERT components	No. of experts value 3–4	I-CVI	Description
Balance	6/6	1.00	Very valid
Eyes	5/6	0.83	Valid
Arm weakness	6/6	1.00	Very valid
Language difficulties	6/6	1.00	Very valid
Extreme headache	5/6	0.83	Valid
Reaction slowed or confusion	6/6	1.00	Very valid
Time to response	6/6	1.00	Very valid

S-CVI/Ave=0.95→meeting validity standards.
Ave=average; BE-ALERT=balance-eyes-arm weakness-language difficulties-extreme headache-reaction slowed or confusion-time to response; I-CVI=item-level content validity index; S-CVI=scale-level content validity index.

sponse options includes visual icons to help users navigate the questions. For example, an arm icon represents the "arm weakness" component, which assesses weakness or paralysis of the arms. If the total BE-ALERT score is >7, the application automatically advises users to take the patient to the hospital immediately.

(3) Results and recommendations

After the form is completed, the application displays a status message. If the total BE-ALERT score is greater than 7, the application displays the message, "High risk, go to the hospital immediately." If no stroke signs are identified (score ≤7), the application displays the message, "No signs of stroke found at this time," and advises further medical evaluation if symptoms persist or worsen.

The design and development stage was completed by compiling BE-ALERT domains and items and integrating them with multimedia-based stroke education features. Initial testing involved experts and potential users to ensure content suitability and ease of use. The resulting BE-ALERT application has the following main functions: (1) identifying stroke symptoms through simple BE-ALERT-based questions; (2) providing a risk indication score and recommendations to seek immediate medical attention; and (3) delivering interactive educational content on risk factors, symptoms, and the importance of the golden period.

The application was reviewed by experts and tested in the community to evaluate content performance, reliability, diagnostic accuracy, and usability.

4. Content Validation

The content validity assessment yielded I-CVI values

ranging from 0.83 to 1.00 and an S-CVI/Ave of 0.95 (Table 2). Reliability testing yielded a Cronbach's α coefficient of .82 and a KR-20 coefficient of .80.

5. Diagnostic Accuracy

Diagnostic accuracy was evaluated using BE-ALERT assessments completed by 500 family caregivers accompanying patients with suspected stroke. According to the neurologist-confirmed reference standard, 120 patients had stroke and 380 were classified as nonstroke. Using the predefined BE-ALERT positivity threshold of a total score >7, 102 accompanying patients were classified as true positives, 312 as true negatives, 68 as false positives, and 18 as false negatives (Table 3).

BE-ALERT demonstrated a sensitivity of 85.0% (95% CI, 77.0%–91.5%), specificity of 82.1% (95% CI, 77.9%–85.7%), PPV of 60.0% (95% CI, 52.5%–67.2%), and NPV of 94.5% (95% CI, 92.1%–97.0%). ROC analysis yielded an AUC of 0.836 (95% CI, 0.792–0.879) (Table 3).

Table 3. Diagnostic Accuracy Tests (N=500)

BE-ALERT	Stroke (+)	Stroke (–)
BE-ALERT (+)	102 (TP)	68 (FP)
BE-ALERT (–)	18 (FN)	312 (TN)

Sensitivity: [TP/(TP+FN)] × 100% = 102/120 = 85.0% (95% CI, 77.0%–91.5%); Specificity: [TN/(FP+TN)] × 100% = 312/380 = 82.1% (95% CI, 77.9%–85.7%); Positive predictive value = [TP/(TP+FP)] × 100% = 102/170 = 60.0% (95% CI, 52.5%–67.2%); Negative predictive value = [TN/(FN+TN)] × 100% = 312/330 = 94.5% (95% CI, 92.1%–97.0%); Area under the receiver operating characteristic curve = 0.836 (95% CI, 0.792–0.879).
BE-ALERT positivity was defined as a total score >7 based on the family caregiver assessment. The reference standard was the neurologist-confirmed diagnosis based on neurological examination and supporting diagnostic investigations.
BE-ALERT = balance-eyes-arm weakness-language difficulties-extreme headache-reaction slowed or confusion-time to response; CI = confidence interval; FN = false negative; FP = false positive; TN = true negative; TP = true positive.

6. Effects of Community Implementation on Stroke Knowledge and Intention to Act

Community implementation of the BE-ALERT application was evaluated among 160 family caregivers. The median stroke knowledge score increased from 65.4 (interquartile range [IQR], 60.0–70.0) before the intervention to 82.1 (IQR, 78.0–88.0) after the intervention (Wilcoxon signed-rank test, p<.001). The median intention-to-act score increased from 3.1 (IQR, 2.0–3.5) before the intervention to 4.5 (IQR, 4.0–5.0) after the intervention (p<.001). The mean SUS score was 74±11 (Table 4).

DISCUSSION

BE-ALERT demonstrated good diagnostic performance, with an AUC of 0.836, sensitivity of 85.0%, specificity of 82.1%, and NPV of 94.5%. These findings suggest that the application can discriminate between patients with and without stroke in community-based screening while maintaining a relatively low likelihood of missed stroke cases. The moderate PPV should be interpreted in relation to disease prevalence and the intended role of BE-ALERT as a screening tool rather than a diagnostic tool. The mean SUS score of 74 also indicates acceptable user experience, consistent with previous studies showing that usable mobile health applications may improve public awareness and timely healthcare seeking.

The high I-CVI values and S-CVI/Ave indicate that the assessment items adequately represented the intended constructs and were judged relevant by the expert panel. Similarly, the Cronbach α and KR-20 coefficients indicate acceptable internal consistency and reliability. Together, these findings support the psychometric quality of BE-ALERT before diagnostic accuracy evaluation. This is consistent with previous studies showing that expert-reviewed digital health assessment tools with high content validity and acceptable internal consistency provide a stronger basis for subsequent diagnostic accuracy testing.

Table 4. Changes in Stroke Knowledge, Intention to Act, and System Usability after Community Implementation (N=160)

	Pretest	Posttest	Δ Median	p
Respondent's knowledge in using the application (n=160)	65.4 (60.0–70.0)	82.1 (78.0–88.0)	+16.7	<.001
Intention to act (n=160)	3.1 (2.0–3.5)	4.5 (4.0–5.0)	+1.4	<.001
SUS score (n=160)	-	74±11	-	-

Values for knowledge and intention to act are presented as median (IQR); SUS values are presented as mean±standard deviation. The p-value was calculated using the Wilcoxon signed-rank test.
IQR = interquartile range; SUS = System Usability Scale.

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Sensitivity and specificity are measures of diagnostic test accuracy. Sensitivity refers to a test's ability to correctly identify individuals with disease, whereas specificity refers to its ability to correctly identify individuals without disease [2]. A model with high sensitivity but low specificity may detect most true-positive cases but generate many false alarms. Conversely, a model with low sensitivity but high specificity may miss clinically important cases. Therefore, diagnostic tools should balance sensitivity and specificity according to clinical needs and intended use [3]. In this study, BE-ALERT demonstrated good overall performance, with high sensitivity and specificity and a moderate PPV, supporting its ability to identify a large proportion of true-positive stroke cases while classifying negative cases with relatively low error.

Stroke is not limited to older adults and can occur in younger populations; however, incidence is most common between ages 45 and 80 years. In Indonesia, public messaging emphasizes early recognition and rapid hospital presentation, including the slogan "SeGeRa Ke RS" [4]. The government also promotes early action through screening approaches such as FAST. Nevertheless, misconceptions persist, including beliefs that stroke can be treated with massage, bloodletting from the ear, or inserting needles into affected body parts, which may delay hospital presentation [5]. In response to these contextual barriers and prior evidence, the researchers developed a community-oriented early stroke detection application to support symptom recognition.

The primary objective of this study was to evaluate the validity of a community-based stroke screening application in families caring for stroke patients. Expert I-CVI results indicated that BE-ALERT was acceptable for community use. After the intervention, participants demonstrated improved knowledge and reported better usability of the application. These findings suggest that the application may help families screen for signs and symptoms of stroke and potential recurrence and seek prompt medical assistance.

Factors contributing to screening failure, recurrence, and stroke complications are often related to delayed detection, suboptimal risk factor management, and barriers to service delivery and patient behavior [6]. Stroke prevalence data are more readily available than incidence data, reflecting limited population-based surveillance in many regions. Much of the available evidence is derived from hospital-based case series, which may show substantial heterogeneity across settings [7]. In addition, prior systematic reviews have noted limited evidence regarding community-based interventions to prevent stroke [8].

In this study, public knowledge of stroke symptoms remained limited, with a substantial proportion of respondents categorized as poor or adequate, underscoring the need for digital, application-based stroke education such as BE-ALERT. This finding aligns with prior studies reporting that public knowledge of stroke warning signs and emergency response remains generally low, despite the implementation of FAST/BE-FAST campaigns in many countries. Video-based e-health interventions and mobile applications have been associated with improved patient and family knowledge of stroke risk factors and symptoms, although they may not consistently outperform conventional education. Therefore, local context and user characteristics should be considered when developing BE-ALERT educational content [9-11].

Respondents' preferences for easily accessible features, audiovisual education, risk recording, and emergency alerts are consistent with literature indicating that age, sex, and education level influence adoption and sustained use of e-health applications [12]. Although smartphone and internet use are widespread, older adults living alone with chronic conditions may have low digital health literacy, which has been associated with sex, age, and education level [13]. Public awareness of stroke symptoms also varies across countries and is not solely determined by national development status. Educational initiatives in schools and mass media may help improve stroke awareness [12]. However, prior reports indicate that only about half of participants demonstrate good stroke awareness, highlighting the need to strengthen stroke education efforts in Thailand [6]. In addition, stroke literacy in a Vietnamese community improved following a single culturally tailored educational session, underscoring the importance of tailored interventions and the need to address barriers related to basic literacy and aging [14].

Limited internet access highlights the need for applications that support offline functionality to expand educational reach. Overall, user-driven digital platforms may help bridge gaps in stroke awareness, improve healthcare-seeking behavior, and enhance community preparedness for stroke emergencies. However, differences between rural and urban areas may reflect not only rurality but also sociodemographic factors such as education, income, and healthcare access. These considerations suggest that digital application-based education may support more effective

understanding than conventional methods in some contexts. Increasing knowledge is important because better understanding of stroke symptoms and risk factors has been associated with earlier detection and reduced treatment delays [15]. Digital health studies often have design limitations, such as small sample sizes within single regions, and therefore may require multicenter validation to assess reliability and generalizability across populations [16]. In addition, onset-to-door time and onset-to-needle time are critical outcomes, yet many digital health studies have not evaluated their effects comprehensively [17]. Future research should consider multicenter designs, long-term clinical impact evaluation, and assessment of cultural factors and digital literacy to improve validity and acceptability.

This study has several limitations. First, the implementation sample was limited to urban areas; therefore, generalizability to rural settings requires further testing. Second, the study did not evaluate the application's impact on onset-to-door time or onset-to-treatment time, although these outcomes are important for stroke-related clinical outcomes. Third, sociocultural factors and community digital literacy were not examined in depth, although they may affect application acceptance. Overall, limitations include a relatively small sample from a single region, the absence of long-term evaluation of onset-to-door outcomes, and incomplete assessment of users' sociocultural and digital literacy factors.

Technology-based health interventions tailored to user needs, together with improved digital health literacy, may support optimal self-care for stroke patients in the digital era [18]. This study is innovative; however, additional evidence regarding long-term clinical outcomes and cross-population validation is needed before BE-ALERT can be recommended as a standard community-based screening approach in Indonesia. Prior work has emphasized the importance of caregiver-oriented, evidence-based mHealth solutions and cross-sector collaboration among healthcare professionals, technology developers, and policymakers to create applications that are accessible, effective, and sustainable [19]. An additional limitation is that BE-ALERT is currently available only in Indonesian and has been implemented only in Indonesia.

The findings suggest that BE-ALERT has promising psychometric and diagnostic properties for community-based stroke screening. The high CVI and acceptable reliability coefficients indicate that the application content is relevant and internally consistent. The observed sensitivity, specificity, NPV, and AUC also suggest that BE-ALERT may help identify individuals with suspected stroke while minimizing missed cases. Community implementation was associated with improved stroke knowledge and stronger intention to seek prompt medical attention, indicating potential educational benefits. The SUS score exceeded the commonly accepted usability threshold, suggesting that the application is generally acceptable to users. Nevertheless, larger multicenter studies are needed before widespread implementation can be recommended. The iterative revision process allowed the application to be refined before finalization by incorporating expert recommendations, diagnostic evaluation findings, and user feedback from implementation testing.

CONCLUSION

This study showed that BE-ALERT is a family-based, community-oriented application for early stroke screening. The application demonstrated good content validity, acceptable reliability, high diagnostic accuracy, and good usability, suggesting that it may support early recognition of stroke symptoms and reduce prehospital delays, particularly for posterior circulation stroke, which may not be identified with the conventional FAST approach. Community implementation improved caregivers' knowledge of stroke symptoms and intention to seek immediate medical care. These findings support the potential integration of BE-ALERT into community stroke education and early detection programs to help family caregivers recognize suspected stroke and facilitate timely access to emergency care.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - LTH, N, TLY, and TWL; analysis - LTH and N; interpretation of the data - LTH; and drafting or critical revision of the manuscript for important intellectual content - LTH, SDMR, M, P, SR, and CA.

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DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding author.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2025.1030.

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Effects of a Clinical Decision-Making Program on Medication Safety Competency among Advanced-Beginner Nurses in Intensive Care Units: A Nonequivalent Control Group Pretest–Posttest Study with a Time-Lagged Design

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Purpose: This study evaluated the immediate and sustained effects of a clinical decision-making program based on Simon's decision-making model on medication safety competency among advanced-beginner nurses in intensive care units. **Methods:** This nonequivalent control group pretest-posttest study used a time-lagged design and included 18 intensive care unit nurses at a tertiary hospital, with 12 assigned to the intervention group and six to the control group. The intervention group participated in a 2-week clinical decision-making program that integrated case-based learning and high-fidelity simulation, whereas the control group received lecture-based education. Clinical decision-making ability, medication safety competency, and safety motivation were measured at baseline and at 2 and 4 weeks after baseline. Near-miss medication error experiences were assessed at baseline and at 4 and 10 weeks. Data were analyzed using the independent t-test, Mann-Whitney U test, and linear mixed models. **Results:** Clinical decision-making ability ($F = 3.94$, $p = .026$), medication safety competency ($F = 4.97$, $p = .011$), safety motivation ($F = 5.20$, $p = .009$), and near-miss medication error experiences ($F = 14.28$, $p < .001$) showed significant group-by-time interaction effects, indicating that outcome trajectories differed between the intervention and control groups. **Conclusion:** These findings suggest that the program may be an educational strategy for strengthening nurses' clinical decision-making during medication administration and improving medication and patient safety in intensive care unit settings.

Key Words: Intensive care units; Decision making; Simulation training; Medication errors; Patient safety

INTRODUCTION

Medication administration based on physicians' prescriptions is a core nursing responsibility that directly affects patient safety. Nurses also bear legal and professional accountability for safe medication administration under the Medical Service Act in Korea [1]. The enactment of the Nursing Act in 2024 further strengthened nurses' accountability for medication safety and underscored their expanded role in patient safety [1,2].

Intensive care units (ICUs) are especially vulnerable to medication errors because of rapid patient deterioration,

frequent emergencies, high patient acuity, and complex treatment regimens [3-5]. Approximately 90% of ICU healthcare professionals have experienced medication errors [3], and these incidents account for a substantial proportion of patient safety events in Korean ICUs [5]. These findings highlight the need for nurses to exercise autonomous clinical judgment during high-risk medication administration.

The risk of medication errors is especially pronounced among advanced-beginner nurses, who are in the transitional stage between novice and competent practice in Benner's developmental model [6]. Although advanced beginners show increasing technical proficiency, they often lack the experiential knowledge and pattern-recognition skills needed for context-sensitive clinical judgment. This creates a "decision-making gap," in which clinical responsibility increases more rapidly than experiential expertise [6,7]. Nurses with 1–3 years of clinical experience have substantial difficulty managing complex medications in ICUs [8,9], indicating that advanced-beginner ICU nurses are a high-risk and educationally vulnerable population that requires targeted medication error-prevention interventions.

Medication administration in ICUs often occurs under time pressure and uncertainty [3-5], and more than half of ICU medication prescriptions contain errors [10]. Although these environmental conditions cannot be directly modified through educational interventions, approximately 93% of these errors are preventable through accurate nursing judgment and timely intervention [10]. Strengthening nurses' clinical decision-making is therefore essential for promoting safe medication administration in complex ICU settings [3-5,10]. However, few studies have examined programs designed to support novice nurses' clinical decision-making during complex medication administration in ICUs [7-9]. Simon's model conceptualizes decision-making as an iterative cycle of intelligence, design, and choice under conditions of bounded rationality and explains how rapid decisions are made in complex environments [11]. In this model, the intelligence, design, and choice stages guide nurses in recognizing medication-related risks, evaluating management alternatives, and selecting the safest course of action; together, these stages provide a structured framework for medication-related clinical decision-making in ICU settings [11-13]. Applying Simon's model improved patient safety competencies among nursing students [12]. More recently, a standalone simulation-based program developed using Simon's model improved medication error-recovery performance among ICU nurses with at least 12 months of clinical experience [13]. However, the effectiveness of a sequential clinical decision-making program for improving medication safety competency among advanced-beginner ICU nurses remains unclear. The present study therefore evaluated the effects of such a program.

Medication safety competency is a key factor in preventing and reducing medication errors [14], including near-miss events [15]. Near-miss medication errors, defined as errors detected before they cause harm to patients, are important indicators of patient safety in the medication process and reflect behavioral aspects of medication safety performance in clinical settings [15,16]. Clinical decision-making ability is a major predictor of medication safety competency and safe medication practices [17,18]. Safety motivation is also important because it helps determine whether nurses consistently translate their competencies into actual safety behaviors in clinical settings [19]. According to Neal and Griffin [19], safety motivation reflects individuals' willingness to exert effort to perform work safely and is an important antecedent of safety behavior. Nurses' motivation and judgmental performance abilities are interrelated and influence the outcomes of their actions in clinical settings [20].

Educational strategies such as case-based learning (CBL) [12,21] and simulation-based training [13,22,23] are widely used to enhance clinical decision-making and medication safety competencies in nursing education. However, because learners in CBL primarily analyze clinical scenarios without directly performing clinical actions, CBL may have limitations in developing the practical performance skills required in complex clinical environments [12]. In contrast, simulation-based training supports both cognitive and experiential learning by enabling nurses to practice clinical decision-making [13,21] and medication administration in realistic clinical situations [13,22,23]. Although simulation-based training improves patient safety-related outcomes, experiential training alone may not always ensure sustained learning outcomes [22,23]. Integrating analytic and experiential learning approaches may therefore provide a more comprehensive strategy for improving medication safety competency in nursing practice [21]. Few studies have examined whether a clinical decision-making process that integrates CBL and simulation leads to sustained behavioral changes in medication safety performance among ICU nurses.

Existing studies of educational interventions for clinical decision-making or medication safety have primarily fo-

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cused on immediate outcomes [22,23] or short-term follow-up assessments of approximately 4 weeks after the intervention [12]. Therefore, the sustained effects of a clinical decision-making program integrating CBL and simulation should be evaluated, particularly through longer-term follow-up of behavioral outcomes, such as near-miss medication error experiences, over 10 weeks.

This study evaluated the immediate and sustained effects of a clinical decision-making program developed to enhance medication safety competency among advanced-beginner nurses in ICUs.

We hypothesized that (H1) participants in the intervention group would show greater improvements over time in clinical decision-making ability, medication safety competency, and safety motivation than participants in the control group and (H2) participants in the intervention group would show greater reductions over time in near-miss medication error experiences than participants in the control group.

METHODS

1. Study Design

This study used a nonequivalent control group pretest–posttest design with a time-lagged structure to evaluate the effectiveness of a clinical decision-making program intended to enhance medication safety competency and safety motivation and reduce near-miss medication error experiences. The time-lagged design was selected because participants were recruited from the same ICU setting, where interaction among nurses could have increased the risk of contamination through informal sharing of educational content and experiences. A time-lagged approach has been used in quasi-experimental intervention studies when individual randomization carries a substantial risk of spillover and contamination between study groups [24]. The study was reported in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guidelines, and the study flow is shown in Figure 1.

2. Study Participants

Participants were recruited from the medical, surgical, emergency, and neurosurgical ICUs of a 930-bed tertiary general hospital in Gangwon-do between January and May 2023. Although the hospital operated five adult ICUs, one unit was unavailable for recruitment because of operational circumstances, including unit management and staff reallocation during the study period. Eligible participants were registered nurses classified as advanced beginners who had more than 12 months and less than 36 months of clinical experience. Neonatal ICU nurses and nurses concurrently participating in other patient safety education programs were excluded. Across the four participating ICUs, 132 registered nurses were employed, of whom 24 met the eligibility criteria. Eighteen eligible nurses provided consent and were included in the study. This study was conducted at the same tertiary hospital as the subsequently published study [13]; however, the two studies were conducted during different periods and recruited different participant groups. Consequently, no participant was enrolled in both studies.

The sample size was calculated using G*Power 3.1.9.2 for an ANOVA with repeated measures, between factors. Assuming an effect size f of 0.40, an α level of .05, a power of 0.95, two groups, three repeated measurements, and a correlation of .50 among repeated measures, the required sample size was 18. The effect size was based on a previous simulation-based in tervention study [22], which used a large effect size of f=.40 for its a priori sample size calculation. Because the sample size calculation assumed equal group allocation and a repeated measures ANOVA, whereas the study used a 2:1 allocation ratio and a covariate-adjusted linear mixed model (LMM), the actual statistical power may have been lower than the planned power. After providing informed consent, participants completed a medication knowledge assessment developed by Kim and Jung [25] solely for group allocation. Participants were then ranked by score and assigned sequentially in a 2:1 pattern (experimental-control-experimental) to balance medication knowledge between the two groups (Figure 1). The 2:1 allocation ratio was adopted to maximize participants' opportunity to receive the educational intervention while maintaining a comparison group. Medication knowledge was assessed after informed consent and before implementation of the time-lagged study design, solely for group allocation. Baseline outcome assessments (T0), including clinical decision-making ability, medication safety competency, safety motivation, and near-miss medication error experiences, were conducted immediately before the educational intervention in each group. Therefore, in the intervention group, T0 was performed approximately 10 weeks after medication knowledge assessment and group alloca-

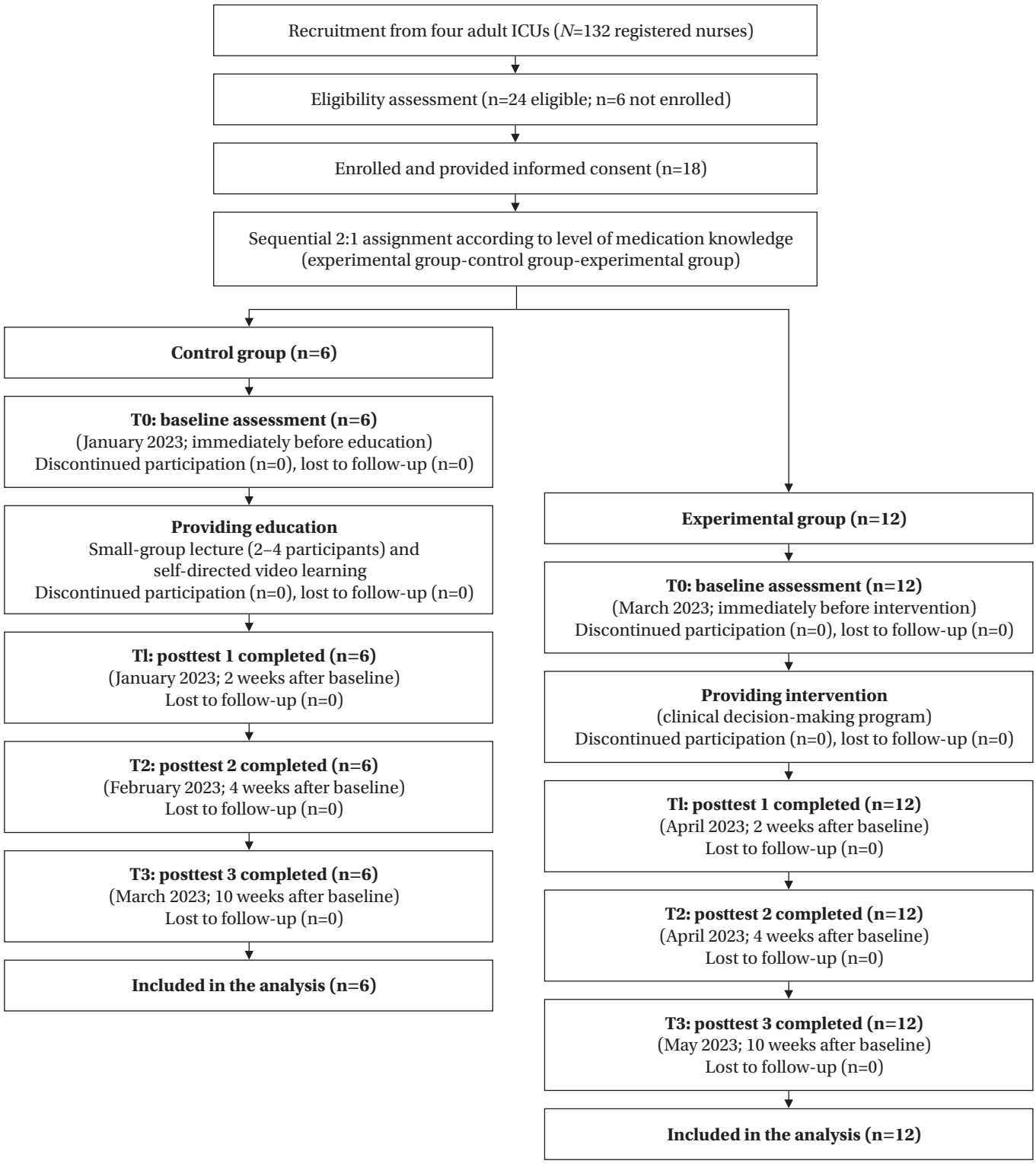

Figure 1. Study design, participant flow, and data collection timeline.
T0 = pretest (clinical decision-making ability, medication safety competency, safety motivation, near-miss medication error experiences); T1 = posttest 1 (clinical decision-making ability, medication safety competency, safety motivation); T2 = posttest 2 (clinical decision-making ability, medication safety competency, safety motivation, near-miss medication error experiences); T3 = posttest 3 (near-miss medication error experiences). Near-miss medication error experiences were assessed only at T0, T2, and T3 because the instrument measured experiences occurring within the preceding 2 weeks. Medication knowledge assessment was conducted before group allocation. Baseline assessment (T0) was performed immediately before the educational intervention in each group; for the intervention group, T0 was conducted approximately 10 weeks after medication knowledge assessment because of the time-lagged study design. ICU = intensive care unit.

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tion because of the time-lagged design. Baseline medication knowledge scores did not differ significantly between the experimental and control groups (14.75±1.66 vs. 14.17±1.94, t=0.67, p=.515).

3. Measurements

1) General characteristics

General characteristics, including age, sex, and educational level, were collected using a questionnaire.

2) Clinical decision-making ability

Clinical decision-making ability was measured using a tool modified and reconstructed by Baek [26] from an instrument developed by Jenkins [27]. The tool includes 40 items scored on a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). Higher scores indicate greater clinical decision-making ability. Cronbach's α was .83 during instrument development [27] and .94 in this study. Permission to use the modified instrument was obtained from Baek [26].

3) Medication safety competency

Medication safety competency was measured using the Medication Safety Competence Scale developed by Park and Seomun [14]. The tool includes 36 items scored on a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). Higher scores indicate greater medication safety competency. Cronbach's α was .96 during instrument development [14] and .98 in this study. Permission to use the instrument was obtained from Park [14].

4) Safety motivation

Safety motivation was measured using a tool adapted from Chung [28]. The tool includes six items rated on a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). Higher scores indicate greater safety motivation. Cronbach's α was .78 in the study by Chung [28] and .73 in this study. Permission to use the instrument was obtained from Chung [28].

5) Near-miss medication error experiences

Near-miss medication error experiences were assessed using items developed by Park and Lee [16] to measure the number of near-miss medication errors experienced during the previous 2 weeks. The instrument includes six items, with higher values indicating more frequent near-miss medication errors. For each item, participants reported 0, 1, 2, 3, or 4 occurrences during the previous 2 weeks; when five or more occurrences were experienced, the actual number of occurrences was recorded. The total score was calculated by summing the frequencies reported across the six items and ranged from 0 to no predefined upper limit. Internal consistency was not calculated because the items represented frequency counts of distinct types of near-miss medication errors rather than reflective indicators of a single latent construct. Permission to use the instrument was obtained from Park [16].

4. Clinical Decision-Making Program

1) Clinical decision-making program development process

The clinical decision-making program was developed in three sequential phases related to the ICU medication process (Figure 2).

Phase 1, evidence-informed program planning, focused on identifying relevant evidence and determining key design elements for the program. A literature review was conducted to identify strategies for enhancing medication safety competencies and preventing medication errors among ICU nurses. Eleven relevant intervention and theoretical studies were reviewed using the keywords "clinical decision-making," "clinical judgment," and "critical thinking," supplemented by manual searches for intervention studies. On the basis of this review and a synthesis of prior intervention studies and decision-making frameworks identified in the literature, three core elements were finalized: (1) program focus, (2) an intervention design framework based on Simon's decision-making model, and (3) educational strategies to guide the structure of program content and learning activities. The program focus was defined as high-alert medication administration in ICUs, where medication errors are most likely to cause severe patient harm. The intervention design was based on Simon's decision-making model [11,12]. Sequential CBL and simulation with iterative reflection were selected as educational strategies because evidence supports active, contextualized learning in medication-related clinical decision-making [11,12,21].

Phase 2, program construction, involved developing the core components and educational content of the intervention. Using Simon's decision-making model [11], clinical decision-making component items for high-alert medication administration in ICUs were developed for each stage of the model—intelligence, design, and choice—to structure the

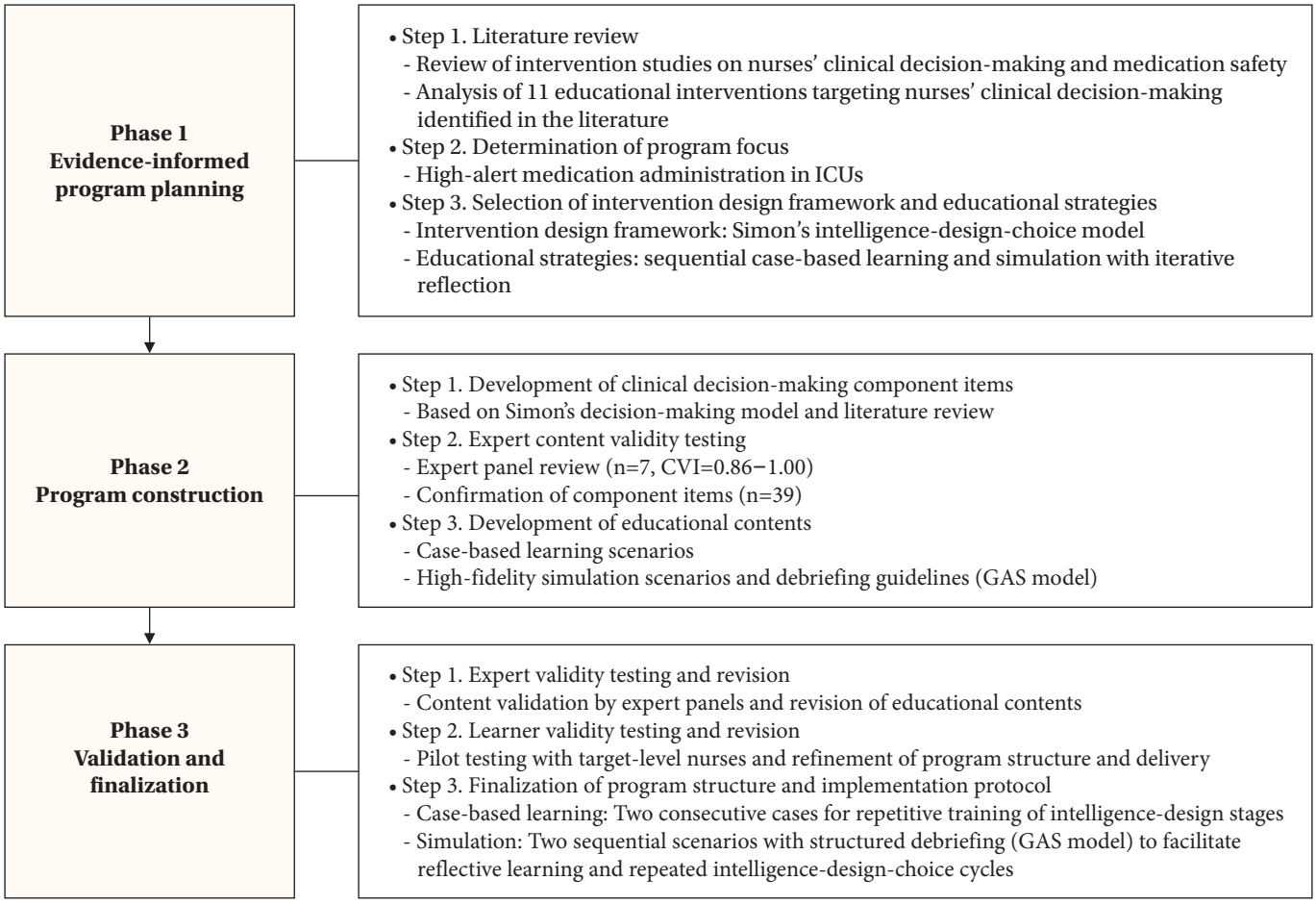

Figure 2. Development process of the clinical decision-making program.
CVI = content validity index; GAS = Gather-Analyze-Summarize; ICU = intensive care unit.

program content. These component items were designed for direct application in CBL and simulation scenarios and included real-world high-risk cases, such as fatal events resulting from undiluted potassium chloride administration [29]. Content validity was evaluated by seven experts: three nursing professors, one medical school professor, and three ICU nurse managers. This process yielded 39 validated items: 13 intelligence items, 12 design items, and 14 choice items, with content validity index values of 0.86–1.00.

The program's educational format was organized around the validated component items. The core educational strategies were CBL and simulation, both of which were designed to apply the intelligence–design–choice cycle in realistic medication situations. The CBL sessions, consisting of two 45-minute cases, were structured as consecutive cases to provide repeated training in the intelligence and design stages using root cause analysis (RCA) techniques [30], including flowcharting, the 5-why method, fishbone diagrams, and brainstorming.

After the CBL sessions, simulation-based training was designed to support the application of decision-making in complex clinical situations [21]. The training consisted of two sequential high-fidelity simulation sessions, each lasting 90 minutes, that focused on high-alert medication administration in ICU settings [23,29]. The simulation scenarios addressed critical cases, including potassium chloride administration and insulin administration in patients with hypotension. The first scenario involved managing a single patient to facilitate focused clinical decision-making, whereas the second involved managing two patients to increase task complexity and simulate competing clinical priorities [31]. These scenarios were intended to promote progressively higher levels of clinical decision-making under conditions of competing priorities and increased task complexity. Together, the components formed a sequentially integrated intervention linking analytic learning through CBL with experiential learning through simulation.

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Phase 3, validation and finalization, involved expert review and learner feasibility testing of the developed program. After iterative modifications based on expert and learner feedback, the final structure, educational sequence, and implementation protocol for the clinical decision-making intervention were determined.

2) Program implementation and data collection procedure

Data collection and the intervention were conducted from January to May 2023 at the training and simulation center of a tertiary general hospital. The study used a nonequivalent control group pretest–posttest design with a time-lagged approach, in which baseline assessments (T0) and subsequent outcome measurements for the experimental group were conducted only after data collection for the control group had been completed. This approach was used to minimize contamination and diffusion effects between groups (Figure 1) [24].

The intervention was delivered by one trained research provider with ICU clinical experience and simulation-based teaching experience. Trained ICU nurses who were not involved in delivering the intervention collected the data. A single-blind procedure was used, in which only the data collectors remained unaware of group assignment until data collection was completed. To ensure consistency and minimize contamination, the same provider delivered all educational sessions using standardized protocols, and participants were instructed not to share intervention materials until study completion.

Outcome measures were assessed at predefined time points in both groups. Clinical decision-making ability, medication safety competency, and safety motivation were measured at T0, 2 weeks after baseline (T1), and 4 weeks after baseline (T2) in both the experimental and control groups. Near-miss medication error experiences were measured at T0, 4 weeks after baseline (T2), and 10 weeks after baseline (T3) in both groups because the instrument's reference period was "the past 2 weeks," which could not be satisfied at T1 [16]. The 10-week follow-up assessment was selected to extend the follow-up period beyond the 4-week assessment used in previous educational intervention studies [12] and to allow sufficient time for improvements in clinical decision-making ability, medication safety competency, and safety motivation to translate into behavioral changes, such as reduced near-miss medication error experiences [32].

(1) Experimental group

The clinical decision-making program consisted of three sequential sessions delivered at weekly intervals over 2 weeks: preparatory education on day 1, CBL on day 7, and simulation training on day 14.

On day 1, immediately after baseline assessment (T0), participants received preparatory education consisting of a 60-minute face-to-face lecture and supplementary self-directed video materials. These materials reinforced the same content and established foundational knowledge of high-alert medication safety. Face-to-face lectures were conducted in small groups of two to four participants, and identical video materials were provided for self-directed learning to ensure consistent instruction.

On day 7, 7 days after baseline, participants attended a 90-minute CBL session involving two consecutive high-alert medication error cases. During this session, participants applied RCA techniques [30] to support the intelligence and design stages of Simon's decision-making cycle. CBL sessions were conducted in pairs, with two participants per session, to facilitate interactive discussion and collaborative problem-solving. This format allowed participants to articulate their reasoning processes, compare perspectives, and jointly construct clinical decisions.

On day 14, 7 days after the CBL session, participants completed a 180-minute simulation program consisting of two high-fidelity simulation scenarios. Each scenario included prebriefing, scenario execution, and structured debriefing. The first scenario involved potassium chloride administration, and the second involved insulin administration in a two-patient scenario that included a patient with hypotension, thereby introducing competing clinical priorities and increasing task complexity [31]. Simulation scenarios were conducted individually so that participants could engage in clinical decision-making and execute actions without external influence, whereas debriefing sessions were conducted in pairs to facilitate reflective learning through shared experience and feedback [33]. Structured debriefing was conducted after the first simulation scenario, and participants applied the feedback from that debriefing to the subsequent scenario. This process enabled iterative reflection and reapplication of the decision-making cycle across scenarios. Debriefing followed the Gather-Analyze-Summarize (GAS) model [33], which facilitated reflective learning and iterative application of the intelligence–design–choice decision-making cycle (Figure 3). To ensure intervention fidelity, all intervention sessions were delivered by the

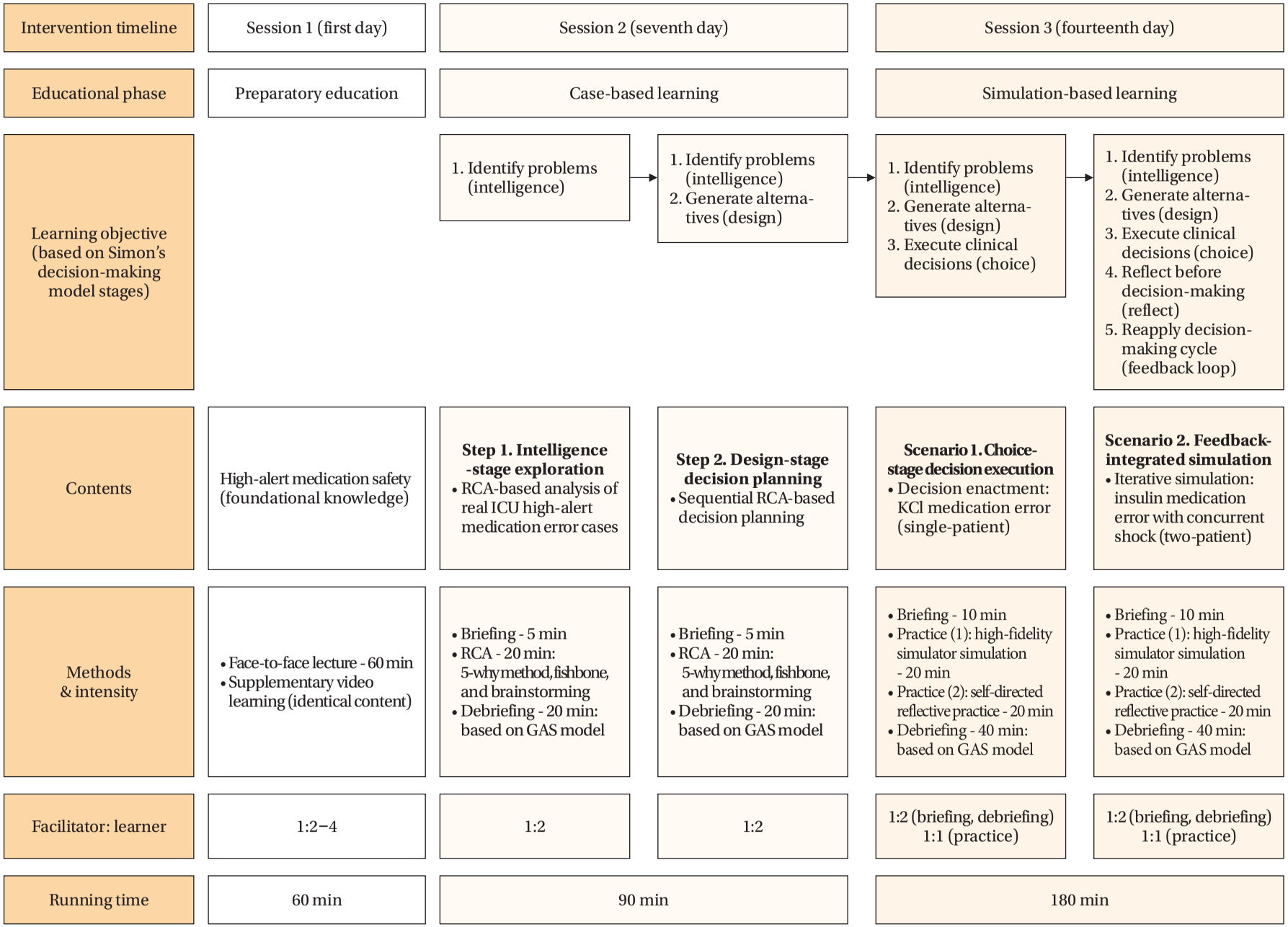

Figure 3. Structure of the clinical decision-making program.

GAS = Gather-Analyze-Summarize; ICU = intensive care unit; KCl = potassium chloride; RCA = root cause analysis.

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same researcher using standardized educational materials, CBL scenarios, simulation scenarios, and structured GAS-based debriefing. In addition, the intervention sessions followed a standardized protocol with a consistent sequence, content, and duration.

(2) Control group

Participants in the control group completed the baseline assessment (T0), followed by a 60-minute face-to-face lecture on clinical decision-making for medication safety. The lecture was delivered to small groups of two to four participants and was accompanied by a structured discussion using high-alert medication error cases and self-directed video materials on applying clinical decision-making during the medication process. However, participants in the control group did not participate in the subsequent CBL or simulation sessions that comprised the full clinical decision-making program.

5. Ethical Considerations

The institutional review board of Yonsei University Wonju Severance Christian Hospital approved the data collection process before the start of the study (Date of approval: 2022/08/24, No. CR322077), and the study was registered with Clinical Research Information Service (CRIS; KCT0009692). Written informed consent was obtained from all participants. Participants were informed of the study purpose, procedures, potential risks and benefits, right to voluntary withdrawal, and measures for ensuring anonymity and confidentiality. Data were collected and stored securely. Paper-based records will be destroyed after 3 years in accordance with the Institutional Review Board-approved data retention policy.

6. Data Analysis

Data were analyzed using IBM SPSS Statistics version 30.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using the Shapiro-Wilk test. Homogeneity was assessed using the χ^2 test and Fisher's exact test for categorical variables, and the independent t-test or Mann-Whitney U test was used for continuous variables according to the results of normality testing. Differences over time between the experimental and control groups were analyzed using an LMM, with group, time, and group-by-time interaction specified as fixed effects. The LMM was considered appropriate because it accommodates correlated repeated measurements, missing observations, and unbalanced longitudinal data and allows flexible specification of the covariance structure [34]. A participant-level random intercept was specified to account for between-participant variability, and a first-order autoregressive (AR[1]) covariance structure was used for repeated measurements because correlations were expected to decrease as the time interval between measurements increased. Fixed effects were tested using F-statistics based on restricted maximum likelihood estimation, and denominator degrees of freedom were calculated using the Satterthwaite approximation. There were no participant dropouts or missing outcome data; therefore, no imputation was performed. Clinical experience was included as a covariate because it differed significantly between groups at baseline. Age was not included because it did not differ significantly between groups and was likely to be closely related to clinical experience. The significance level was set at $p < .05$.

RESULTS

1. Homogeneity of General Characteristics and Baseline Characteristics between the Two Groups

The homogeneity tests for general characteristics and baseline variables showed no statistically significant differences between the experimental and control groups, except in clinical experience in the current department. Clinical experience differed significantly between groups ($Z = -2.12$, $p = .034$), with the control group having longer clinical experience than the experimental group (28.67 ± 4.27 months vs. 22.58 ± 5.87 months) (Table 1).

2. Hypothesis Verification

The LMM hypothesis-testing results are presented in Table 2. Because clinical experience differed significantly between groups at baseline, it was included as a covariate in the LMM analysis ($Z = -2.12$, $p = .034$). Significant group-by-time interaction effects were observed for clinical decision-making ability ($F = 3.94$, $p = .026$), medication safety competency ($F = 4.97$, $p = .011$), safety motivation ($F = 5.20$, $p = .009$), and near-miss medication error experiences ($F = 14.28$, $p < .001$). At the 4-week assessment, the estimated marginal mean differences between the intervention and control groups were 18.33 (95% confidence interval [CI],

Table 1. Homogeneity of General Characteristics and Baseline Variables between the Two Groups (N = 18)

Characteristics	Categories	Exp (n = 12)	Cont (n = 6)	Test	
		n (%) or M ± SD		χ^2/t/Z	p
General characteristics					
Sex	Male	4 (33.3)	3 (50.0)	-	.627†
	Female	8 (66.7)	3 (50.0)		
Age (year)		25.42 ± 1.51	28.17 ± 3.54	–1.96‡	.050
Educational level	Bachelor's degree	12 (100.0)	5 (83.3)	-	.333†
	Graduate-level education (master's or higher)	0 (0.0)	1 (16.7)		
Clinical experience (month)		22.58 ± 5.87	28.67 ± 4.27	–2.12‡	.034
Homogeneity of baseline variables					
Clinical decision-making ability		135.83 ± 8.22	136.67 ± 10.60	–0.19§	.856
Medication safety competency		133.67 ± 10.57	129.83 ± 11.27	–0.94‡	.348
Safety motivation		21.50 ± 1.93	20.83 ± 4.12	0.38§	.719
Near-miss medication error experiences		11.33 ± 2.23	12.50 ± 2.88	–0.95§	.355

Cont = control group; Exp = experimental group; M = mean; SD = standard deviation; †Fisher's exact test; ‡Mann-Whitney U test; §Independent t-test.

4.59 to 32.07) for clinical decision-making ability, 27.68 (95% CI, 14.29 to 41.07) for medication safety competency, and 5.98 (95% CI, 3.71 to 8.25) for safety motivation. At the 10-week assessment, the estimated marginal mean difference for near-miss medication error experiences was –6.24 (95% CI, –8.52 to –3.96), favoring the intervention group.

DISCUSSION

This study showed that a clinical decision-making program integrating CBL and simulation was associated with more favorable changes over time in clinical decision-making ability, perceived medication safety competency, safety motivation, and self-reported near-miss medication error experiences among advanced-beginner nurses. Because clinical decision-making is a key determinant of medication safety competency [17], the program may be an educational strategy for strengthening both clinical decision-making ability and medication safety competency in this population. These improvements may ultimately contribute to medication error prevention in ICU settings and thereby benefit patients.

The significant improvement in clinical decision-making ability observed in the intervention group suggests that the program enhanced nurses' capacity to identify medication-related problems, generate appropriate alternatives, and select safe actions in complex ICU situations. This effect may be attributable to the program's deliberate focus on advanced-beginner nurses, who often face increasing clinical responsibility despite limited experiential knowledge [18]. Unlike a subsequently published Simon model-based program that primarily emphasized repeated simulation practice and feedback to improve medication error-recovery performance among ICU nurses with at least 12 months of clinical experience [13], the present program used a sequential educational approach tailored to advanced-beginner nurses. Specifically, CBL was designed to strengthen the intelligence and design stages of Simon's decision-making cycle, whereas simulation integrated the intelligence, design, and choice stages in realistic medication administration scenarios. By structuring learning activities around Simon's intelligence–design–choice cycle [11], the program supported the systematic organization of clinical information and a structured approach to medication-related decision-making. Unlike conventional medication education, which tends to emphasize procedural knowledge and task performance [18,22,23], this intervention explicitly targeted decision-making processes across the medication administration cycle. Integrating CBL and simulation enabled repeated application of these processes in realistic high-alert medication scenarios, consistent with prior studies showing that structured decision-making education using CBL and simulation enhances nurses' clinical reasoning in high-risk contexts [18,22,23].

Medication safety competency showed a significant group-by-time interaction effect, indicating that the intervention had both immediate and sustained effects on safe medication practices among advanced-beginner nurses.

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Table 2. Effects of the Clinical Decision-Making Program on Dependent Variables (N = 18)

Variables	Groups	Pre	Post 1 (2 weeks)	Post 2 (4 weeks)	Post 3 (10 weeks)	Test		
		M ± SD				Source	F	p
Clinical decision-making ability	Exp (n = 12)	135.83 ± 8.22	150.33 ± 9.55	148.67 ± 12.83	-	Clinical experience	0.51	.478
						G	8.37	.006
	Cont (n = 6)	136.67 ± 10.60	127.50 ± 21.57	128.83 ± 17.75		T	0.21	.810
						G × T	3.94	.026
Medication safety competency	Exp (n = 12)	133.67 ± 10.57	158.33 ± 5.85	155.08 ± 12.96	-	Clinical experience	0.08	.784
						G	21.80	< .001
	Cont (n = 6)	129.83 ± 11.27	130.00 ± 12.59	126.83 ± 23.11		T	4.15	.022
						G × T	4.97	.011
Safety motivation	Exp (n = 12)	21.50 ± 1.93	24.67 ± 1.83	24.83 ± 1.99	-	Clinical experience	0.00	.948
						G	25.91	< .001
	Cont (n = 6)	20.83 ± 4.12	21.17 ± 1.47	19.00 ± 2.45		T	2.40	.102
						G × T	5.20	.009
Near-miss medication error experiences	Exp (n = 12)	11.33 ± 2.23	-	9.92 ± 1.00	9.25 ± 0.45	Clinical experience	0.82	.378
						G	12.77	.003
	Cont (n = 6)	12.50 ± 2.88	-	10.67 ± 2.88	15.00 ± 3.52	T	4.12	.019
						G × T	14.28	< .001

The near-miss medication error experience variable was not assessed at Post 1.
Cont = control group; Exp = experimental group; G = group; M = mean; Post 1 = 2 weeks after baseline; Post 2 = 4 weeks after baseline; Post 3 = 10 weeks after baseline; Pre = pretest; SD = standard deviation; T = time.

Despite their limited clinical experience, advanced-beginner nurses are expected to perform appropriate clinical actions while relying on fragmented knowledge [6,7]. This mismatch may create a gap between expected and actual performance and increase the risk of medication errors [8,9]. Unlike previous educational interventions that often used CBL [12] or simulation [13,22,23] independently, this study used a sequential learning structure aligned with Simon's decision-making cycle [11,12] and designed for the developmental characteristics of advanced-beginner nurses. In the initial phase, CBL guided participants through RCA of high-alert medication error scenarios [30], strengthening their analytic reasoning and their ability to identify risks and generate appropriate alternatives during the intelligence and design stages of Simon's clinical decision-making process [11-13,21]. Simulation then enabled participants to engage actively in decision-making in complex clinical situations [13,31], requiring them to recognize risks, make decisions, and execute safe medication practices in real time [22,23]. In this way, simulation supported enactment of the choice stage by integrating intelligence and design into actual clinical decision-making performance [13,22,23]. Sequential integration of CBL and simulation within an experiential learning cycle has been proposed from an educational design perspective [35]. Although previous clinical decision-making training for nurses primarily relied on either CBL or simulation alone [12,13,22,23], the sequential use of both methods in the present study may have contributed to sustained improvements in medication safety competency. This integration may have helped translate analytic understanding into context-specific clinical actions among advanced-beginner nurses. In addition, compared with prior decision-making education delivered over 4 weeks [12], the present 2-week program may be clinically feasible while still allowing repeated application of analytic and experiential learning.

The clinical decision-making program significantly enhanced safety motivation, suggesting that the intervention influenced not only competency development but also the motivational processes underlying safe medication behaviors. Safety motivation may be strengthened when learners perceive the personal relevance and potential consequences of clinical risks [19,20]. In the present study, CBL using real high-alert medication error scenarios, including fatal potassium chloride administration events [29], likely increased the salience of medication-related risk and professional responsibility by exposing participants to realistic, consequential clinical situations. This exposure may have strengthened safety motivation [12,19,20]. Simulation sessions further required participants to perform clinical deci-

sion-making and medication administration tasks actively, followed by structured reflective debriefing based on the GAS model. This process may have promoted deeper reflection on performance outcomes and reinforced accountability for safe practice [31,33]. Experiential learning focused on high-risk medication administration decisions likely increased learners' sense of responsibility for medication safety [19] and further strengthened their motivation to practice safely.

The program also resulted in a significant reduction in self-reported near-miss medication error experiences. Although this finding suggests positive changes in participants' perceived medication safety practices, it should not be interpreted as direct evidence of objectively improved clinical performance because the outcome was assessed by self-report. Near-miss medication error experiences are meaningful indicators of perceived medication safety practices [15,16], and reductions in self-reported near-miss experiences may indicate that participants perceived greater use of decision-making strategies during medication administration. Unlike medication safety competency and safety motivation, which may respond more immediately to educational interventions, behavioral outcomes tend to emerge more gradually as newly acquired knowledge and motivation are integrated into clinical practice [19]. In this study, the delayed reduction observed at the 10-week follow-up may reflect reinforcement and consolidation of decision-making strategies through repeated application in clinical settings [32]. Although previous studies have reported short-term follow-up outcomes, such as outcomes at 4 weeks [12], or have primarily focused on immediate post-intervention effects [22,23], the extended 10-week follow-up in the present study allowed delayed behavioral changes to be detected. This supports the interpretation that integrated decision-making education may contribute to sustained improvements in perceived medication safety practices, although future studies using objective performance measures are needed to determine whether these changes translate into actual clinical performance. The use of a time-lagged design, together with a 2-week recall window for near-miss measurements, supports the interpretation that the observed self-reported changes were maintained over time rather than reflecting only immediate post-intervention responses [16]. Self-reported near-miss medication error experiences increased in the control group at the final follow-up. Because these data were self-reported, this finding may reflect increased awareness of, or willingness to report, near-miss medication error experiences over time rather than an actual increase in medication errors.

More broadly, the significant group-by-time interaction effects reflected different outcome trajectories between the intervention and control groups, with changes occurring in both groups rather than only in the intervention group. The declines in clinical decision-making ability and safety motivation observed in the control group may also have contributed to the interaction effects. Because the groups were recruited sequentially, temporal changes in workload, staffing, the clinical environment, or other organizational factors may have influenced these trajectories independently of the intervention.

These findings support the value of a Simon model-based clinical decision-making education program that integrates CBL and simulation to promote safe medication practices among advanced-beginner ICU nurses. Rather than focusing only on procedural skills, the intervention showed how structured decision-making training aligned with learners' developmental needs could support the transition from knowledge acquisition to safe clinical performance [6,7]. The program may therefore be a practical educational approach for improving clinical decision-making ability and medication safety competency among advanced-beginner ICU nurses. Given nurses' legal and professional accountability for safe medication administration [1,2] and the high prevalence of medication-related patient safety risks in ICU settings [3-5], incorporating developmentally tailored decision-making education into in-service training programs may be a practical strategy for strengthening patient safety practices in critical care environments.

This study has several limitations. First, it was conducted in a single tertiary hospital with a small sample size, which limits generalizability. The small sample size reflected the limited number of eligible advanced-beginner ICU nurses available during the recruitment period. In addition, the 2:1 allocation ratio resulted in a small control group, which may have reduced statistical precision; therefore, the findings should be interpreted with caution. The intervention and control groups also differed substantially in total educational exposure time (330 vs. 60 minutes); therefore, the observed effects cannot be attributed solely to the sequential CBL–simulation structure and may partly reflect differences in educational exposure time. Because multiple outcome variables were evaluated, the possibility of increased Type I

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error should also be considered. Although data collectors were blinded to group assignment, blinding of the intervention provider and participants was not feasible. In addition, because the intervention was delivered by a single researcher, researcher allegiance or implementation bias may have influenced intervention delivery despite the use of standardized educational materials and procedures. The observed improvements should therefore be interpreted as perceived rather than objectively demonstrated changes, and reductions in self-reported near-miss medication error experiences may reflect increased awareness of, or willingness to report, near-miss events rather than actual reductions in medication errors. Future studies should incorporate objective indicators, such as electronic medical records or incident reporting data. Although a time-lagged design was used to minimize contamination and diffusion between groups, sequential recruitment may have introduced temporal bias because changes in the clinical environment over time could have influenced outcomes independently of the intervention. In addition, because randomization was not feasible, causal inferences should be made with caution. Despite these limitations, this study contributes to the literature by demonstrating improvements in decision-making-related competencies and measurable reductions in near-miss medication error experiences as indicators of behavioral change in medication safety practice.

CONCLUSION

In this study, a clinical decision-making program integrating CBL and simulation based on Simon's model was associated with more favorable outcome trajectories over time in clinical decision-making ability, perceived medication safety competency, safety motivation, and self-reported near-miss medication error experiences than those observed in the control group. These findings suggest that the program may be an educational strategy for supporting clinical decision-making during medication administration and improving medication and patient safety in ICU settings. Future studies should replicate these findings using larger and more diverse samples to enhance generalizability. Further research is also needed to examine the long-term effects of this program. Future studies should incorporate objective indicators, such as electronic medical records or incident reporting data, to evaluate the impact of decision-making-based educational interventions on medication safety and error reduction more accurately.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - SYP and HKH; data collection - SYP; analysis - SYP; interpretation of the data - SYP and HKH; and drafting or critical revision of the manuscript for important intellectual content - SYP and HKH.

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DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding author.

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Factors Associated with Comfort after Liver Resection among Patients with Hepatocellular Carcinoma

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Purpose: Guided by Kolcaba's Comfort Theory, this study aimed to identify predictors of comfort among patients with hepatocellular carcinoma after liver resection. **Methods:** This cross-sectional predictive correlational study included 132 patients with hepatocellular carcinoma who underwent liver resection in Wenzhou, China. Demographic and clinical characteristics, including age, were collected. Comfort, pain severity, pain interference, perceived social support, and early mobilization were assessed using validated instruments. Data were analyzed using descriptive statistics, the independent-samples t-test, one-way analysis of variance, Pearson correlation coefficients, and standard multiple linear regression. **Results:** Participants reported a moderate overall level of comfort. In the multiple regression model, pain interference ($\beta = -.25$, $p = .008$) and perceived social support ($\beta = .39$, $p < .001$) were significant predictors of comfort, with perceived social support emerging as the strongest predictor. Pain severity ($\beta = -.09$, $p = .287$), age ($\beta = -.09$, $p = .264$), and early mobilization ($\beta = .01$, $p = .909$) were not significant predictors. The regression model was statistically significant and explained 27% of the variance in comfort ($R^2 = .27$, $F = 9.20$, $p < .001$). **Conclusion:** Perceived social support and pain interference were independently associated with postoperative comfort among patients with hepatocellular carcinoma following liver resection. These findings highlight the importance of comprehensive pain management and nursing strategies that strengthen social support; such interventions may help improve postoperative comfort and recovery.

Key Words: Hepatectomy; Hepatocellular carcinoma; Pain; Patient comfort; Social support

INTRODUCTION

In 2022, liver cancer ranked as the sixth most commonly diagnosed cancer and the third leading cause of cancer-related death worldwide [1]. Hepatocellular carcinoma (HCC) is the most common primary liver malignancy, and liver resection (LR) remains the primary curative treatment for patients with early-stage disease and adequate liver function [2-4]. Although LR can provide favorable long-term survival, it is a complex surgical procedure associated with substantial physiological stress and postoperative complications, including coagulopathy, pulmonary complications, biliary leakage, post-hepatectomy liver failure, and renal dysfunction [5]. Furthermore, many patients undergoing LR have underlying liver disease, cirrhosis, or a history of anticancer treatment, which may complicate postoperative recovery.

During recovery from LR, patients commonly experience

multidimensional discomfort, including pain, fatigue, gastrointestinal symptoms, emotional distress, and reduced social engagement. These issues extend beyond transient postoperative symptoms and may impair recovery, limit participation in rehabilitation activities, and reduce overall well-being [6]. Evidence indicates that effective postoperative symptom management is associated with better recovery after hepatectomy. For example, optimized analgesic strategies have been associated with less postoperative pain and shorter hospital stays, underscoring the clinical relevance of comfort as a key outcome during postoperative recovery [7]. Nevertheless, evidence regarding the factors associated with comfort among patients with HCC following LR remains limited.

This study was guided by Kolcaba's Comfort Theory [8,9], which conceptualizes comfort as an immediate outcome of meeting patients' comfort needs while accounting for intervening variables and health-seeking behaviors that promote recovery and well-being. Within this framework (Figure 1), postoperative pain was conceptualized as a healthcare need in the physical context of comfort because it represents bodily discomfort following LR. To comprehensively represent this construct, pain was operationalized in two dimensions: pain severity, representing the intensity of physical discomfort, and pain interference, representing the extent to which pain disrupts physical functioning, daily activities, and recovery-related behaviors. Together, these dimensions represent unmet physical comfort needs that may impede the attainment of comfort. Age and perceived social support were treated as intervening variables that may influence patients' comfort experiences but are not readily modifiable through healthcare interventions. Although Kolcaba conceptualized health-seeking behaviors as consequences of enhanced comfort, early mobilization was examined in this study as a behavioral factor that might also contribute to comfort by supporting physical recovery, reducing postoperative complications, and increasing functional independence. Comfort level was conceptualized as enhanced comfort, the theory's primary outcome. Based on this framework, pain severity, pain interference, perceived social support, age, and early mobilization were hypothesized to predict comfort among patients with HCC following LR.

Pain and early mobilization may both shape postoperative recovery after LR. Pain is among the most common postoperative symptoms and has been associated with impaired physical functioning, delayed recovery, psychological distress, and reduced comfort among surgical patients [10,11]. By contrast, early mobilization is a central component of enhanced recovery after surgery (ERAS) pathways for patients undergoing LR. Evidence suggests that early ambulation supports circulation, pulmonary function, muscle strength, and functional independence, thereby facilitating recovery and potentially improving patient comfort [12,13]. Studies of ERAS pathways have also found associations between early mobilization and shorter hospital stays, fewer postoperative complications, and better patient-reported recovery outcomes [6]. Because pain may limit participation in postoperative activity, whereas mobilization may promote recovery and independence, both factors may play important roles in patients' comfort after LR.

Beyond physical recovery factors, patient characteristics and psychosocial resources may also influence comfort. Social support is an important resource during recovery from cancer surgery, and greater perceived support has been associated with better psychological adjustment, more effective coping, and greater comfort during hospitalization [13,14]. Age may affect comfort through differences in physiological reserve and coping capacity; older patients may be more susceptible to delayed recovery and reduced comfort after liver surgery [12,13]. These findings

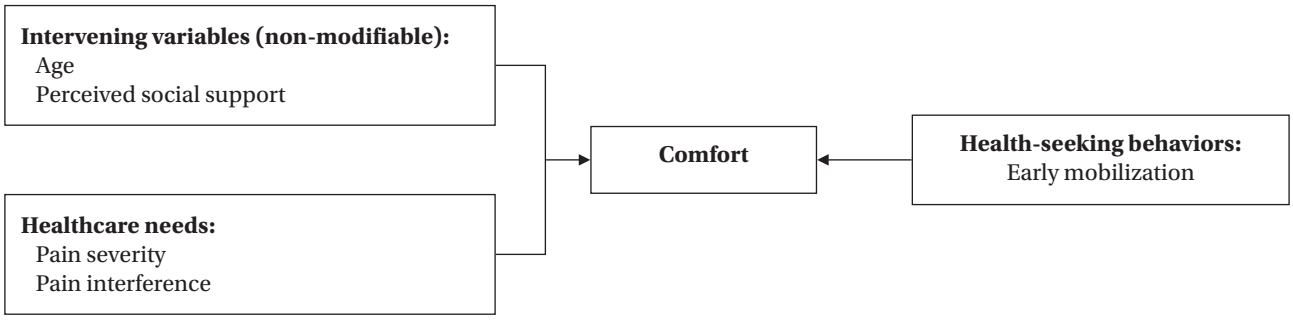

Figure 1. Conceptual framework based on Kolcaba's Comfort Theory.

suggest that pain, early mobilization, perceived social support, and age may contribute to differences in comfort among patients with HCC following LR.

However, evidence regarding the relationships of these factors with comfort among patients with HCC after LR remains limited. Moreover, few studies have examined pain, perceived social support, age, and early mobilization simultaneously within a theory-based framework. Therefore, guided by Kolcaba's Comfort Theory, this study examined whether these factors statistically predicted comfort among patients with HCC after LR.

METHODS

1. Study Design

This cross-sectional predictive correlational study examined factors statistically associated with comfort among patients with HCC following LR. This study was reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

2. Setting and Participants

The study was conducted in the Department of Hepatobiliary and Pancreatic Surgery at the First Affiliated Hospital of Wenzhou Medical University, Wenzhou, Zhejiang Province, China. The target population comprised adult patients diagnosed with HCC who had undergone LR and were in the early postoperative recovery period, defined as 3 to 7 days after surgery. The inclusion criteria were as follows: (1) age ≥18 years, permitting adult informed consent and independent questionnaire completion while allowing the inclusion of young and middle-aged adults, among whom the incidence of liver cancer is increasing in China; (2) no evidence of cognitive impairment, defined as a Mini-Cog score ≥3 for patients aged ≥60 years, to support adequate comprehension and the reliability of self-reported responses; and (3) the ability to communicate in Mandarin or the Wenzhou dialect, enabling participants to understand the study procedures and questionnaire items and reducing language-related measurement bias.

The exclusion criteria were intended to reduce clinical heterogeneity and potential confounding of comfort outcomes. Patients were excluded if they were (1) currently receiving chemotherapy or radiotherapy, as treatment-related adverse effects such as fatigue, nausea, and pain could independently affect comfort and recovery; (2) diagnosed with metastatic disease, because systemic symptom burden and recovery trajectories may differ from those of patients with localized disease; (3) experiencing severe postoperative complications, such as hepatic encephalopathy, gastrointestinal hemorrhage, tumor rupture, or shock, because clinical instability could preclude safe participation and substantially alter perceived comfort; or (4) diagnosed with a psychiatric disorder, as these conditions could affect emotional processing, symptom perception, or the validity of psychometric assessments of comfort and related constructs.

Participants received no monetary or non-monetary compensation. The required sample size was estimated using G*Power ver. 3.1 (University of Düsseldorf, Düsseldorf, Germany) for multiple linear regression. Assuming a significance level of $\alpha = .05$, a statistical power of .90, a moderate effect size of $f^2 = .15$, and five predictors, the minimum required sample was calculated to be 116 participants. To account for potential missing data and participant attrition, approximately 20% more participants were recruited, resulting in a target sample of 144 participants. Consequently, 144 questionnaires were distributed. After data screening, seven questionnaires with incomplete responses and four cases identified as statistical outliers based on at least one of the following criteria were excluded: absolute standardized residuals >3.0, Cook's distance >1.0, or Mahalanobis distance with $p < .001$; one participant who withdrew while completing the questionnaire was also excluded. The final analytic sample comprised 132 participants, which exceeded the minimum required sample size.

3. Instruments

All instruments were administered with permission from their original developers and the authorized translators of the Chinese-language versions.

1) General characteristics

The demographic and clinical characteristics collected were age, sex, marital status, education level, annual family income, the presence of an accompanying family member during hospitalization, viral hepatitis status, body mass index (BMI), current smoking, smoking history, current and previous alcohol consumption, postoperative length of hospital stay, cancer stage, type of surgery, and postoperative complications.

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2) Comfort

Comfort was assessed using the General Comfort Questionnaire (GCQ), developed by Kolcaba [15]. The validated Chinese version, translated and culturally adapted by Zhu et al. [16], contains 30 items covering four domains: physical, psychospiritual, sociocultural, and environmental comfort. Items are rated on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree), with higher total scores indicating greater comfort. Negatively worded items were reverse-coded before analysis. Total scores range from 30 to 120 and were categorized as indicating low (<60), moderate (60–90), or high (>90) comfort. Mean item scores were also categorized as indicating low (<2), moderate (2–3), or high (>3) comfort. The GCQ demonstrated excellent internal consistency in a validation study (Cronbach α=.92) [16]. Internal consistency was acceptable in the present study (Cronbach α=.86).

3) Pain

Pain was assessed using the Brief Pain Inventory (BPI), developed by Cleeland [17] and translated into Chinese by Wang et al. [18]. Consistent with Kolcaba's Comfort Theory, postoperative pain was conceptualized as an unmet physical comfort need and was assessed in two dimensions: pain severity and pain interference. The BPI contains four items assessing pain severity—worst, least, average, and current pain—and seven items assessing interference with general activity, walking ability, work, mood, sleep, enjoyment of life, and relationships with others. Each item is rated on an 11-point numerical scale from 0 to 10, with higher scores indicating greater pain severity or interference. In this study, pain severity and pain interference were analyzed as separate independent variables. A mean score was calculated for each dimension and categorized as mild (1–4), moderate (5–6), or severe (7–10), according to established criteria [19]. The Chinese version of the BPI has demonstrated excellent internal consistency (Cronbach α=.92) [18], and internal consistency was also high in the present study (Cronbach α=.87).

4) Early mobilization

Early mobilization was assessed using the Johns Hopkins Highest Level of Mobility scale (JH-HLM), a single-item ordinal measure of the highest observed level of patient mobility during the first 24 postoperative hours. The eight consecutively scored categories are as follows: 1, lying only; 2, performing activities in bed; 3, sitting at the edge of the bed; 4, transferring to a chair; 5, standing for ≥1 minute; 6, walking ≥10 steps; 7, walking approximately ≥7.5 m (≥25 ft); and 8, walking approximately ≥75 m (≥250 ft) [20]. Higher scores indicate greater postoperative mobility. The JH-HLM has demonstrated excellent test–retest and interrater reliability, with intraclass correlation coefficients (ICCs) ranging from 0.92 to 0.99 [20]. In this study, JH-HLM assessments were performed by the first author and nurses working on the study ward who had received standardized training before data collection. Interrater reliability was evaluated to confirm measurement consistency, and agreement between assessors was excellent (ICC=1.00).

5) Perceived social support

Perceived social support was assessed using the Multidimensional Scale of Perceived Social Support (MSPSS), developed by Zimet et al. [21] and translated into Chinese by Huang et al. [22]. The MSPSS contains 12 items rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The items are grouped into three subscales assessing support from family, friends, and others. Higher scores indicate greater perceived social support. Total scores range from 12 to 84 and are categorized as indicating low (12–36), moderate (37–60), or high (61–84) perceived social support. The MSPSS has demonstrated good internal consistency in Chinese populations (Cronbach α=.84), and internal consistency was similarly high in the present study (Cronbach α=.86).

4. Data Collection

Data were collected from July 2024 through January 2025 using purposive sampling. Before recruitment, permission was obtained from the attending physicians, and ward nurses identified potentially eligible patients through the hospital medical information system. The nurses approached these patients initially and referred those who expressed interest to the research team. A member of the research team then provided detailed verbal and written information about the study purpose, procedures, risks, and benefits. After written informed consent had been obtained, eligibility was confirmed according to the inclusion and exclusion criteria. Demographic and clinical characteristics were obtained from participants and extracted from their electronic medical records. All questionnaire data were collected during a single study visit conducted 3 to 7 days after surgery. Recruitment continued until the target number of questionnaires had been distributed.

5. Ethical Considerations

Ethical approval was obtained from the Ethics Committee of Burapha University, Thailand (No. G-HS044/2567), and the Ethics Committee of the First Affiliated Hospital of Wenzhou Medical University, China (No. KY2024-122). All participants were informed that participation was voluntary and that they could withdraw at any time without penalty. Written informed consent was obtained before data collection. Participant anonymity was protected through the use of unique identification codes. Data were stored in encrypted electronic files accessible only to the research team. The data will be retained securely for 3 years after study completion and then permanently deleted.

6. Data Analysis

Data were analyzed using IBM SPSS ver. 29.0 (IBM Corp., Armonk, NY, USA). Statistical significance was defined as $p < .05$. Frequencies, percentages, means, standard deviations, and ranges were used to summarize participant characteristics and study variables. Annual family income was the only variable with missing responses: 52 participants (39.4%) did not disclose this information. To avoid listwise deletion and potential non-response bias, these cases were coded as a separate category ("Not disclosed") and retained in all analyses. After income responses had been handled in this manner, no other missing data remained, and the full analytic sample of 132 participants was retained. Standard multiple linear regression using the enter method was performed to examine whether pain severity, pain interference, early mobilization, perceived social support, and age statistically predicted comfort.

Although education level ($F = 3.93$, $p = .005$), current smoking ($t = -2.53$, $p = .013$), and postoperative length of hospital stay ($F = 3.16$, $p = .016$) were significantly associated with comfort in univariate analyses, they were not included in the final regression model. Variable selection was guided by Kolcaba's Comfort Theory and the study conceptual framework rather than by statistical significance alone. Education level and current smoking were not identified as theoretically relevant predictors of comfort within the framework. Length of hospital stay may reflect postoperative recovery status and clinical progress rather than function as an antecedent determinant of comfort. Therefore, only variables with theoretical relevance and temporal precedence were retained in the regression model.

The assumptions of multiple linear regression were evaluated before analysis. Linearity was assessed using scatterplots of comfort against each predictor. Independence of errors was supported by a Durbin-Watson statistic of 2.128. The normality of residuals was evaluated using histograms and normal P-P plots, and homoscedasticity was assessed using residual plots. Variance inflation factors ranged from 1.05 to 1.40, indicating that multicollinearity was not a concern. Cook's distances were all well below 1, with a maximum of 0.11, and standardized residuals ranged from –1.75 to 2.40, indicating that no remaining observation was highly influential.

RESULTS

1. Participant Characteristics

Participants' demographic and clinical characteristics are summarized in Table 1. The mean age was 58.47 ± 10.96 years (range, 32–79 years), and the largest proportion of participants were aged 61–70 years (29.5%). Most participants were male (82.6%) and married (97.7%), and the most frequently reported education level was junior high school (36.4%). Annual family income was not disclosed by 39.4% of participants, while 47.7% had an annual family income of 10,000 to less than 100,000 Chinese yuan. Most participants (93.9%) were accompanied by a family member during hospitalization.

Regarding clinical characteristics, 90.2% of participants had hepatitis B virus infection, and 56.8% had a BMI within the normal range. With respect to smoking, a history of smoking was reported by 61.4% of participants, and 40.2% were current smokers. Current alcohol consumption was reported by 36.4% of participants, whereas 56.8% reported previous alcohol use. The mean postoperative length of hospital stay was 9.83 ± 3.91 days, and 78.0% of participants remained hospitalized for 7 to 14 days after surgery. Stage IA HCC was the most common disease stage (50.8%), followed by stage IIIA disease (31.8%). Among the 107 participants who underwent laparoscopic surgery, 63 (58.9%) underwent hepatectomy. Most participants experienced no postoperative complications (91.7%), whereas 3.0% experienced two or more complications.

2. Descriptive Statistics for the Study Variables

As shown in Table 2, observed total comfort scores ranged

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Table 1. Univariate Analysis of Comfort according to Patient Characteristics (N=132)

Characteristics	Categories	n (%)	Comfort score M±SD or M±SD (range)	t or F (p)
Age (year)	32–40	7 (5.3)	91.43±8.68	0.92 (.454)
	41–50	29 (22.0)	87.07±8.31	
	51–60	34 (25.8)	85.65±6.46	
	61–70	39 (29.5)	85.59±8.00	
	71–79	23 (17.4)	86.52±9.46	
Mean age (year)			58.47±10.96 (32–79)	
Sex	Male	109 (82.6)	85.94±7.63	−1.41† (.162)
	Female	23 (17.4)	88.52±9.49	
Marital status	Married	129 (97.7)	86.49±8.06	0.89† (.376)
	Widowed	3 (2.3)	82.33±3.51	
Education	No formal education	17 (12.9)	81.88±6.93	3.93 (.005)
	Primary school	41 (31.1)	86.95±7.25	
	Junior high school	48 (36.4)	87.88±8.00	
	Senior high school	17 (12.9)	82.71±6.34	
	University or above	9 (6.8)	91.44±10.93	
Annual family income, CNY‡	10,000≤100,000	63 (47.7)	86.41±8.44	0.64 (.593)
	100,000≤160,000	11 (8.3)	84.26±6.20	
	160,000–250,000	6 (4.5)	90.00±10.00	
	Not disclosed	52 (39.4)	86.38±7.64	
Family accompaniment during hospitalization	Yes	124 (93.9)	86.52±8.00	0.73† (.514)
	No	8 (6.1)	84.38±6.70	
Viral hepatitis status	Hepatitis B	119 (90.2)	86.21±7.92	0.61 (.544)
	Hepatitis B and C	1 (0.8)	94.00	
	No	12 (9.1)	87.58±9.19	
BMI (kg/m^2)	Underweight (<18.5)	4 (3.0)	83.75±2.99	0.68 (.508)
	Normal weight (18.5–24.9)	75 (56.8)	85.91±8.29	
	Overweight or obesity (≥25)	53 (40.2)	87.28±7.85	
Current smoking	Yes	53 (40.2)	84.28±6.76	−2.53† (.013)
	No	79 (59.8)	87.81±8.49	
Smoking history	Yes	81 (61.4)	86.65±7.87	0.47† (.640)
	No	51 (38.6)	85.98±8.28	
Current alcohol consumption	Yes	48 (36.4)	84.92±6.96	−1.61† (.110)
	No	84 (63.6)	87.24±8.48	
Past alcohol consumption	Yes	75 (56.8)	86.63±8.25	0.38† (.703)
	No	57 (43.2)	86.09±7.74	
Postoperative length of hospital stay (day)	<7	17 (12.9)	91.59±7.70	3.16 (.016)
	7–14	103 (78.0)	85.47±7.67	
	15–21	9 (6.8)	89.33±7.95	
	22–28	2 (1.5)	78.50±13.44	
	>28	1 (0.8)	83.00	
Mean postoperative length of hospital stay (day)			9.83±3.91 (4–29)	
Cancer stage	IA	67 (50.8)	86.28±7.84	0.28 (.842)
	IB	19 (14.4)	86.16±7.16	
	IIA	4 (3.0)	90.00±16.55	
	IIIA	42 (31.8)	86.33±7.89	
Surgical approach	Open surgery	25 (18.9)	86.08±7.62	0.09 (.986)
	Laparoscopic surgery§	107 (81.1)	86.47±8.13	
	Hepatectomy	63 (58.9)	86.49±8.30	
	Hepatectomy and cholecystectomy	39 (36.4)	86.31±8.23	
	Hepatectomy with other procedures	4 (3.7)	88.25±7.00	
	Da Vinci robot-assisted surgery	1 (0.9)	84.00	

(Continued on the next page)

Table 1. Continued

Characteristics	Categories	n (%)	Comfort score M ± SD or M ± SD (range)	t or F (*p*)
Postoperative complications	Venous thrombosis of the lower extremities	2 (1.5)	85.00 ± 1.41	0.23 (.951)
	Abdominal infection	2 (1.5)	83.50 ± 3.54	
	Pleural effusion	1 (0.8)	85.00	
	Chyle leakage	2 (1.5)	83.00 ± 2.83	
	Two or more complications	4 (3.0)	84.00 ± 10.03	
	None	121 (91.7)	86.61 ± 8.17	

BMI = body mass index; CNY = Chinese yuan; M = mean; SD = standard deviation; †t-test; ‡7.34 CNY = 1 US dollar; §Laparoscopic surgery (n = 107) included hepatectomy, hepatectomy and cholecystectomy, hepatectomy with other procedures, and Da Vinci robot-assisted surgery.

Table 2. Range, Mean, and Standard Deviation of Comfort, Pain Severity, Pain Interference, Early Mobilization, and Perceived Social Support among Participants (*N* = 132)

Variables	Possible range	Actual range	M ± SD	Level
Overall comfort	30–120	69–109	86.39 ± 8.01	Moderate
Physical	1–4	1.80–3.80	2.87 ± 0.43	Moderate
Psychospiritual	1–4	2.30–3.90	2.88 ± 0.27	Moderate
Environmental	1–4	2.00–3.43	2.71 ± 0.28	Moderate
Sociocultural	1–4	2.25–4.00	3.04 ± 0.37	High
Pain severity	0–10	0–3.5	1.32 ± 0.96	Mild
Pain interference	0–10	0–9.14	1.61 ± 2.01	Mild
Walking†	0–10	0–10	2.68 ± 2.81	Mild
Working†	0–10	0–10	2.48 ± 3.14	Mild
General activity†	0–10	0–10	1.73 ± 2.73	Mild
Mood†	0–10	0–10	1.36 ± 2.45	Mild
Sleep†	0–10	0–10	1.27 ± 2.54	Mild
Enjoyment of life†	0–10	0–10	0.92 ± 2.27	Mild
Relations with others†	0–10	0–10	0.84 ± 1.98	Mild
Early mobilization	1–8	2–8	3.34 ± 1.58	–
Perceived social support	12–84	42–84	64.67 ± 9.37	High

M = mean; SD = standard deviation; †Pain interference dimension.

from 69 to 109, with a mean of 86.39 ± 8.01, indicating a moderate level of comfort. Among the four comfort domains, sociocultural comfort had the highest mean item score (3.04 ± 0.37), followed by psychospiritual comfort (2.88 ± 0.27) and physical comfort (2.87 ± 0.43). Environmental comfort had the lowest mean item score (2.71 ± 0.28). Pain severity scores ranged from 0 to 3.5, with a mean of 1.32 ± 0.96, corresponding to mild pain. Pain-interference scores ranged from 0 to 9.14 on the 0–10 scale, with a mean of 1.61 ± 2.01, corresponding to mild interference. The mean early-mobilization score was 3.34 ± 1.58, corresponding to a mobility level between sitting at the edge of the bed and transferring to a chair. Perceived social support scores ranged from 42 to 84, with a mean of 64.67 ± 9.37, indicating high perceived social support.

3. Differences in Comfort According to Participant Characteristics

Differences in comfort scores according to participants' demographic and clinical characteristics are presented in Table 1. Comfort scores differed significantly across education levels (F = 3.93, $p = .005$), current smoking (t = −2.53, $p = .013$), and categories of postoperative length of hospital stay (F = 3.16, $p = .016$). No significant differences in comfort scores were found according to age group, sex, marital status, annual family income, family accompaniment during hospitalization, viral hepatitis status, BMI, history of smoking, alcohol consumption, cancer stage, surgical approach or procedure, or postoperative complications.

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4. Correlations among the Main Variables

Pearson correlation coefficients among age, pain severity, pain interference, early mobilization, perceived social support, and comfort are presented in Table 3. Pain severity and pain interference were negatively correlated with comfort (r = –.25, p = .003 and r = –.28, p = .001), indicating that greater pain severity and interference were associated with lower comfort. Perceived social support was positively correlated with comfort (r = .42, p < .001), indicating that greater perceived social support was associated with higher comfort. Early mobilization was positively but non-significantly correlated with comfort (r = .13, p = .141), and age was not significantly correlated with comfort (r = –.10, p = .274). Age was negatively correlated with early mobilization (r = –.23, p = .008), indicating that older participants tended to have lower early mobilization scores. Early mobilization was also positively correlated with perceived social support (r = .17, p = .048), indicating that participants who perceived greater social support tended to have higher mobility scores.

5. Factors Associated with Comfort

Standard multiple linear regression was used to examine whether age, pain severity, pain interference, early mobilization, and perceived social support statistically predicted comfort when entered simultaneously into the model. The model assumptions were evaluated and considered adequately met. The overall regression model was statistically significant and explained 27% of the variance in comfort (R^2 = .27, F = 9.20, p < .001) (Table 4). Pain interference (β = –.25, p = .008) and perceived social support (β = .39, p < .001) were significant independent predictors of comfort, with perceived social support having the largest standardized coefficient. Pain severity (β = –.09, p = .287), age (β = –.09, p = .264) and early mobilization (β = .01, p = .909) were not significant predictors.

DISCUSSION

Guided by Kolcaba's Comfort Theory, this study examined postoperative comfort as a multidimensional construct encompassing physical, psychospiritual, sociocultural, and environmental dimensions among patients with HCC following LR. Participants reported a moderate level

Table 3. Correlations among Comfort, Age, Pain Severity, Pain Interference, Early Mobilization, and Perceived Social Support (N = 132)

Variables	Age	Pain severity	Pain interference	Early mobilization	Perceived social support	Comfort
	r (p)					
1. Age	1					
2. Pain severity	–.02 (.807)	1				
3. Pain interference	–.19 (.028)	.48 (< .001)	1			
4. Early mobilization	–.23 (.008)	–.06 (.480)	–.10 (.246)	1		
5. Perceived social support	–.13 (.133)	–.10 (.243)	–.00† (.975)	.17 (.048)	1	
6. Comfort	–.10 (.274)	–.25 (.003)	–.28 (.001)	.13 (.141)	.42 (< .001)	1

†The exact correlation coefficient between pain interference and perceived social support was –.003.

Table 4. Factors Associated with Comfort in Patients with HCC (N = 132)

Variables	B	SE	β	t (p)	Tolerance†	VIF
(Constant)	70.84	6.16		11.50 (< .001)		
Age	–0.07	0.06	–.09	–1.12 (.264)	.89	1.13
Pain severity	–0.79	0.73	–.09	–1.07 (.287)	.75	1.34
Pain interference	–0.98	0.36	–.25	–2.72 (.008)	.71	1.40
Early mobilization	0.05	0.41	.01	0.11 (.909)	.91	1.11
Perceived social support	0.34	0.07	.39	5.06 (< .001)	.95	1.05
R^2 = .27, adjusted R^2 = .24, F = 9.20, p < .001						

B = unstandardized regression coefficient; β = standardized regression coefficient; HCC = hepatocellular carcinoma; SE = standard error; VIF = variance inflation factor; †Tolerance statistic used to assess multicollinearity.

of postoperative comfort during hospitalization. This finding suggests that, despite the substantial physical and psychological burden associated with LR, patients experienced an intermediate level of comfort across multiple domains during early recovery. This finding is consistent with a previous study reporting moderate postoperative comfort [23]. The observed comfort level may partly reflect improvements in perioperative management, including the implementation of ERAS protocols and national initiatives promoting comfort-oriented nursing care in China [24]; however, these factors were not directly measured in the present study. Consistent with the conceptual framework derived from Kolcaba's Comfort Theory, perceived social support and pain interference emerged as significant predictors of comfort in the multivariable model, whereas pain severity, early mobilization, and age did not. These findings emphasize the relevance of social support and pain-related functional limitations to postoperative comfort among patients with HCC.

Perceived social support was the strongest predictor of postoperative comfort. This finding is consistent with Kolcaba's assertion that interpersonal relationships and supportive interactions contribute to comfort, particularly within the sociocultural and psychospiritual domains [8]. Patients with HCC may experience uncertainty related to cancer treatment, postoperative recovery, and future health, making emotional, informational, and practical support especially relevant during hospitalization. Support from family members and significant others may reduce anxiety, strengthen emotional security, and facilitate adaptation to postoperative challenges, thereby contributing to comfort across multiple domains. The positive association between perceived social support and comfort in this study is consistent with previous findings in hospitalized and oncology populations [13]. Greater social support has also been associated with less fear of disease progression and better psychosocial adjustment among patients with HCC after hepatectomy [25]. Similarly, a study of patients undergoing coronary artery bypass graft surgery found that greater perceived social support was associated with greater postoperative comfort, highlighting the importance of supportive interpersonal relationships during recovery [26]. Collectively, these findings support nursing strategies that actively engage family members and strengthen patients' support networks during recovery after LR.

Pain interference also emerged as a significant predictor of comfort among patients following LR. Unlike pain severity, pain interference reflects the extent to which pain disrupts functioning, including mobility, sleep, mood, and social interaction. The findings suggest that the functional consequences of pain may be more closely related to comfort than pain intensity alone. Within Kolcaba's Comfort Theory, such limitations may affect several dimensions of comfort simultaneously [8]. Restrictions on movement and rest may reduce physical comfort, while associated emotional distress may diminish psychospiritual comfort. Reduced participation in family interactions and daily activities may also affect sociocultural comfort. Pain interference may therefore capture a broader aspect of postoperative recovery than pain intensity alone. This interpretation is consistent with studies indicating that postoperative interventions addressing pain-related functional limitations are associated with better recovery experiences and greater comfort [27].

Notably, pain severity was associated with comfort in the bivariate analysis but was not independently associated with comfort in the multivariable model. One possible explanation is that pain interference captures the broader functional consequences of pain and may therefore account more fully for variation in postoperative comfort than pain intensity alone. Previous evidence has linked pain interference to impaired daily functioning and lower quality of life in cancer populations [28]. From the perspective of Comfort Theory, comfort reflects the patient's overall experience rather than isolated symptom intensity [8]. Consequently, postoperative pain assessment should include not only pain intensity but also the effects of pain on sleep, mobility, daily activities, mood, and social participation. Nursing interventions directed at pain-related functional limitations may therefore be more relevant to comfort than strategies focused exclusively on reducing pain intensity.

Early mobilization did not significantly predict comfort in the multivariable model. After adjustment for pain severity, pain interference, perceived social support, and age, the early-mobilization score contributed little additional explanatory value in this sample. Previous research has suggested that associations between early mobilization and postoperative outcomes may operate in part through reductions in pain and complications [29], which may explain the non-significant direct effect in the present study. Larger prospective studies are needed to clarify this relationship.

Age was not independently associated with comfort in

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the multivariable model. Within Kolcaba's framework, age is conceptualized as an intervening variable that shapes responses to health-related experiences without directly determining comfort. Previous studies have reported inconsistent associations between age and comfort-related outcomes among hospitalized patients [30,31]. In the present sample, modifiable factors such as perceived social support and pain-related functional limitations showed stronger associations with comfort than chronological age.

This study has several limitations. First, the cross-sectional design precludes causal or temporal inferences regarding the relationships among pain severity, pain interference, perceived social support, early mobilization, age, and comfort. In addition, data were collected during the early postoperative period, 3 to 7 days after surgery, and variation in assessment timing may have influenced participants' responses. Because comfort, pain, and perceived social support were measured at a single time point, the direction of the observed associations cannot be established. In particular, although perceived social support was positively associated with comfort, reverse causality cannot be excluded: patients experiencing greater comfort may have been more likely to perceive or report higher levels of social support, rather than social support necessarily leading to increased comfort. Second, the use of purposive sampling at a single tertiary hospital may limit the generalizability of the findings to other institutions, regions, and patient populations. Third, although the instruments demonstrated satisfactory reliability and validity in previous cancer populations, they were not developed specifically for patients with HCC undergoing LR. Consequently, they may fail to fully capture symptoms, functional experiences, and comfort-related concerns specific to liver surgery. Future research should consider disease- and procedure-specific measures to more comprehensively assess postoperative recovery and comfort. Finally, the use of self-reported measures may have introduced response bias, and the regression model did not include all potentially relevant factors. Longitudinal studies with larger and more diverse samples are needed to clarify the temporal relationships among social support, comfort, and other postoperative factors and to examine changes in comfort over time.

CONCLUSION

Guided by Kolcaba's Comfort Theory, this study demonstrated that patients with HCC following LR generally reported a moderate level of postoperative comfort during hospitalization. Perceived social support and pain interference were independently associated with comfort, with perceived social support emerging as the strongest predictor. Pain severity, age, and early mobilization were not independently associated with comfort in the multivariable model. These findings extend the application of Kolcaba's Comfort Theory to patients with HCC following LR and suggest that postoperative comfort is associated with perceived social support and pain interference rather than pain intensity or demographic characteristics alone. From a clinical perspective, the findings support the integration of strategies to strengthen social support and minimize pain interference as key components of comfort-focused postoperative nursing care. Longitudinal studies are needed to examine changes in comfort over time and to evaluate additional factors and interventions related to postoperative comfort in this population.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

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DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding author.

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Factors Associated with Employment Status and Sex Differences in Occupational Continuity among Cancer Survivors: A Cross-Sectional Study Using the Korea National Health and Nutrition Examination Survey

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Purpose: This study examined sociodemographic, clinical, and symptom-related factors associated with current employment among cancer survivors and described sex-based differences in occupational continuity. **Methods:** This cross-sectional study used data from the 2019 and 2021 Korea National Health and Nutrition Examination Survey. The sample included cancer survivors aged 19 to 65 years who did not have multiple primary cancers or missing data (n = 289). Employment status was categorized as employed or non-employed. Sociodemographic factors (age, sex, education, marital and household characteristics, household income, and private insurance), clinical factors (time since diagnosis, cancer type, current cancer status, and comorbidity), and symptom-related factors (pain, fatigue, depression, memory problems, and sleep difficulties) were evaluated using hierarchical logistic regression. Weighted descriptive analyses were performed to examine sex-based differences in occupational continuity. **Results:** Overall, 56.6% of participants were employed. In the final model, male sex was associated with higher odds of employment (odds ratio [OR], 4.69; 95% confidence interval [CI], 2.21–9.94; $p < .001$), whereas monthly household income below 3 million Korean won was associated with lower odds of employment (OR, 0.41; 95% CI, 0.19–0.88; $p < .05$). Sleep difficulties were non-significantly associated with lower odds of employment (OR, 0.64; 95% CI, 0.41–1.00; $p = .051$). No clinical factor was significantly associated with employment. Male participants were more likely than female participants to retain their longest-held occupation (58.3% vs. 30.9%). **Conclusion:** Employment among cancer survivors was associated with sex and household income, and occupational continuity differed by sex. Although sleep difficulties were not statistically significant in the final model, sleep assessment and sex-sensitive vocational support may be useful components of survivorship nursing care.

Key Words: Cancer survivors; Employment; Occupations; Socioeconomic factors; Sleep

INTRODUCTION

Advances in medical technology and the expansion of national cancer-control policies have substantially improved early detection and treatment outcomes, shifting cancer from a predominantly fatal disease toward a chronic condition compatible with long-term survival [1,2]. This shift is also evident in Korea: the total number of prevalent cancer cases reached approximately 2.73 million, and 1.70 million survivors (62.1%) had survived for more than five years after diagnosis, an increase of more than 110,000 from the previous year [3].

For cancer survivors living longer after diagnosis, income generation and economic stability are essential to sustaining life after treatment. Even after treatment is completed, survivors require regular follow-up, recurrence surveillance, and ongoing health management, all of which can contribute to persistent financial burden through medical expenses, transportation costs, caregiving expenses, reduced working hours, and income loss [4]. Although copayment-reduction policies in Korea have alleviated part of this burden, out-of-pocket expenses for services not covered by insurance remain substantial [5]. Because approximately half of all cancer survivors are of working age [6], employment interruption or reduced work participation may affect not only survivors themselves but also the economic stability of their families [7]. Employment has also been associated with recovery of social roles, self-efficacy, psychological stability, and social reintegration after cancer [8,9].

Despite the importance of work participation, maintaining employment or returning to the labor market remains challenging for many cancer survivors. This process is shaped not only by willingness to work but also by post-treatment physical and psychological conditions, symptom burden, social support, and the occupational environment [10]. Cancer survivors have higher levels of anxiety and depression than the general population and often experience multiple symptoms, including sleep disturbance and fatigue [11-13]. These symptoms may reduce quality of life, social functioning, and work performance. Workplace support, job security, and opportunities for work adjustment have also been suggested as important contextual factors in maintaining employment or returning to work [7,8,14]. Therefore, employment status among cancer survivors should be understood in relation to sociodemographic and clinical characteristics as well as symptom and functional status.

Previous studies have examined factors associated with return to work and employment status among cancer survivors, but their findings have been inconsistent. For sociodemographic factors, Chen et al. [15] reported that women were more likely than men to return to work, whereas Kang et al. [16] found that women were more likely to experience work cessation after cancer diagnosis. Chen et al. [15] identified older age as a barrier to return to work, whereas Johnsson et al. [17] found no significant association between age and return to work. Findings on marital status and economic factors have also varied. Ahn et al. [18] reported that having a spouse and lower household income were negatively associated with employment maintenance, whereas Johnsson et al. [17] reported no significant association between marital status and return to work. Kang et al. [16] further suggested that the economic role within the family may be related to work cessation.

Inconsistent findings have also been reported for clinical factors, symptoms, and functional status. Chen et al. [15] and Kang et al. [16] reported that advanced stage, chemotherapy, and recurrence were associated with a lower likelihood of return to work or with work cessation, whereas Arndt et al. [19] found that cancer stage was associated with return to work but that cancer type and adjuvant treatment were not clearly related to this outcome. Lopez-Faneca et al. [10] also suggested that disease status, including remission, progression, and recurrence, may influence labor-market outcomes. Regarding symptoms, Tan et al. [20] reviewed cancer-related symptoms such as fatigue, depression, cognitive impairment, pain, and insomnia and found that associations with work outcomes varied by symptom and outcome measure. Similarly, Sohn et al. [21] included fatigue and sleep quality in a study of Korean breast cancer survivors, but the final factors associated with return to work were marital status, time since diagnosis, anxious attachment, and quality of working life. These findings suggest the need to examine clinical status together with specific symptom and functional factors, including pain, fatigue, depression, memory problems, and sleep difficulties.

Individual and clinical characteristics may also be linked to employment status and occupational changes after cancer diagnosis. Kang et al. [16] reported that work cessation, leave, and changes in employment status were associated with sociodemographic, clinical, work-related, and psychological factors. Mehnert et al. [22] noted that work par-

ticipation among cancer survivors has typically been assessed using binary employment status or sick-leave duration, whereas outcomes such as work retention, career choices, and job position after returning to work have been examined less often. Comparing survivors' longest-held occupation with their current occupation may therefore provide additional information about their position in the labor market.

Overall, prior evidence indicates that employment status among cancer survivors is associated with sociodemographic characteristics, clinical status, and symptom and functional status. However, previous studies have often focused on specific cancer types, individual symptoms, or return-to-work experiences, and variation in variables and outcome measures has limited comparisons of the relative influence of these factors. Evidence on sex-based differences also remains limited, although Korean studies have reported that women experience greater employment disruption after cancer diagnosis [23,24]. Therefore, using nationally representative data, this study examined sociodemographic, clinical, and symptom-related factors associated with current employment among cancer survivors and described sex-based differences in occupational continuity.

METHODS

1. Study Design

This cross-sectional study used data from the 2019 and 2021 Korea National Health and Nutrition Examination Survey (KNHANES) [25,26]. KNHANES is an annual, nationally representative survey conducted by the Korea Disease Control and Prevention Agency using a multistage, stratified cluster-sampling design. Because each survey year uses an independent probability sample rather than following the same individuals over time, participant overlap between the 2019 and 2021 waves was not expected by design. The study is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

2. Study Samples

A total of 15,200 individuals participated in the 2019 and 2021 KNHANES. These survey years were selected because the Health-related Quality of Life Instrument with 8 Items (HINT-8), the source of the symptom-related variables in this study, was administered in 2019 and 2021 but not in 2020. Among respondents, 659 reported a history of cancer diagnosis. Adults aged 19 to 65 years were retained (n = 343) to focus on cancer survivors who could still participate in the labor market. After participants with multiple primary cancers were excluded (n = 10), 333 participants remained. Multiple primary cancers were excluded because more complex diseases and treatment trajectories may influence employment differently from employment after a single primary cancer. After cases with missing values in the variables of interest were further excluded (n = 44), 289 participants were included in the final analysis (Supplementary Figure 1).

3. Measurements

1) Occupational characteristics

Employment status was assessed using a single item from the KNHANES health interview survey that asked whether respondents had worked for at least 1 hour for pay or at least 18 hours as unpaid family workers during the previous week. Temporary leave was counted as working. Respondents who answered "yes" were classified as employed, whereas those who answered "no" were classified as non-employed.

Working hours per week were assessed as the self-reported average number of hours worked per week, including overtime and night work but excluding meal breaks. Values were summarized descriptively among employed respondents.

Employment type was assessed among employed respondents using the survey item on type of work performed. Employment type was categorized as wage worker, self-employed worker or employer, or unpaid family worker and summarized descriptively.

Occupational continuity was derived from two separate survey items. Employed respondents reported their current occupation, and all adult respondents reported the occupation they had held for the longest period during their lifetime, regardless of current employment status. Both items were coded using the same major groups of the 7th Korean Standard Classification of Occupations, allowing the two codes to be compared directly. Four categories were defined: (1) retained longest-held occupation, when the two occupation codes were identical; (2) current occupation different from longest-held occupation, when both

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occupations were reported but the codes differed; (3) currently non-employed with a previous longest-held occupation, when no current occupation was recorded but a longest-held occupation was reported; and (4) continuously non-employed, when neither occupation was reported. This classification reflects the current correspondence between longest-held and current occupational status at the time of the survey and does not indicate occupational changes after cancer diagnosis.

2) Symptom-related variables

Symptom-related problems were measured using five items from HINT-8, a Korean instrument that assesses health-related quality of life during the previous week. The five selected items assessed pain, fatigue, depression, memory problems, and sleep difficulties and were chosen because previous studies have linked these symptoms to labor-market outcomes among cancer survivors [20,21]. Each item was rated on a 4-point scale indicating an increasing level of problem, so higher scores indicated more severe symptom-related problems. Each item was analyzed separately rather than as part of a summed index.

3) General and clinical characteristics

General participant characteristics included age, sex, educational level, marital status, head-of-household status, household size, monthly household income, and private insurance status. Clinical characteristics included cancer type, current cancer status, time since diagnosis, comorbidity, and healthcare utilization, defined as inpatient use within the previous year and outpatient use within the previous 2 weeks. Comorbidity was defined as having ever been diagnosed with, or currently having, at least one chronic condition other than cancer. The specific survey items, response categories, and recoding procedures for all study variables are presented in Supplementary Table 1.

4. Data Collection and Procedure

This study utilized publicly available raw data and did not involve additional data collection or direct participant contact. The 2019 and 2021 KNHANES raw datasets were downloaded from the KNHANES website (https://knhanes.kdca.go.kr) after registration and agreement to the data use policy [25,26]. The two annual datasets were subsequently merged for analysis.

5. Ethical Considerations

This study was exempt from review by the Institutional Review Board of Kangbuk Samsung Hospital (IRB No. KBSMC 2026-04-061) because it analyzed publicly available, deidentified data and involved no direct participant contact or additional data collection.

6. Data Analysis

All analyses accounted for the complex-sampling design of KNHANES, including its multistage, stratified cluster sampling, sampling weights, strata, and primary sampling units. When the 2019 and 2021 datasets were combined, an integrated weight was generated according to the KNHANES analytic guidelines for the eighth survey period. Because the survey duration was equivalent across the two years, the annual health interview and examination survey weight (wt_itvex) was multiplied by an integration proportion of 1/2 rather than by a survey-district ratio, following Korea Disease Control and Prevention Agency guidance specific to the eighth period. Descriptive statistics were used to summarize participant characteristics. Differences between employed and non-employed groups were examined using complex-sample t-tests for continuous variables and design-adjusted chi-square tests for categorical variables.

To identify factors associated with employment status, hierarchical logistic regression analyses were performed. In these analyses, employed status was coded as 1 (event) and non-employed status as 0. Three models were constructed sequentially: Model 1 included sociodemographic variables, Model 2 additionally included clinical variables, and Model 3 further included symptom-related variables. The sample included 156 employed and 133 non-employed participants, and the full model contained 23 non-intercept parameters, yielding an event-to-parameter ratio of approximately 6.8 (156/23). Accordingly, the results were interpreted conservatively, with emphasis placed on the direction and consistency of associations rather than on the precise magnitude of individual estimates. Intercorrelations among the symptom items were examined using Pearson correlation coefficients to assess potential multicollinearity. Model explanatory power was summarized using Nagelkerke R^2 as a descriptive pseudo-R^2 index.

Occupational continuity was not modeled as an outcome; instead, weighted descriptive analyses were used to

examine sex-based differences in its distribution. All statistical analyses were performed using IBM SPSS ver. 27.0 (IBM Corp., Armonk, NY, USA), and statistical significance was set at $p < .05$.

RESULTS

1. General Characteristics of the Study Participants

Participant characteristics are presented in Table 1. A total of 289 cancer survivors were included in the analysis. The mean age was 51.9 years (standard error [SE] = 0.71), and 68.5% of participants were female. Most participants had at least 12 years of education (86.3%) and were married (93.0%). Approximately half were heads of household (51.9%), and most lived in one- or two-person households (74.1%).

Regarding household income, 74.8% of participants reported a monthly household income of 3 million Korean won (KRW) or higher, and 92.3% had private insurance.

Table 1. Characteristics of Participants (N=289, Weighted N=1,133,708)

Characteristics	M ± SE or % (SE)	Unweighted n
General and clinical characteristics		
Age (year)	51.90 ± 0.71	289
Sex		
Male	31.5 (3.3)	84
Female	68.5 (3.3)	205
Education		
Less than 12 years of education	13.7 (2.3)	50
12 years of education or more	86.3 (2.3)	239
Marital status		
Married	93.0 (1.9)	271
Unmarried	7.0 (1.9)	18
Head of household		
Yes	51.9 (3.3)	153
No	48.1 (3.3)	136
Household size		
1 or 2	74.1 (2.9)	216
3 or more	25.9 (2.9)	73
Household income		
< 3 million KRW/month	25.2 (2.8)	86
≥ 3 million KRW/month	74.8 (2.8)	203
Private insurance		
Yes	92.3 (1.6)	262
No	7.7 (1.6)	27
Time since diagnosis (year)	5.62 ± 0.20	289
Type of cancer		
Thyroid cancer	33.4 (3.5)	92
Breast cancer	15.9 (2.4)	49
Stomach cancer	9.1 (1.9)	30
Colon cancer	8.8 (1.8)	27
Cervical cancer	3.9 (1.2)	13
Lung cancer	2.4 (0.9)	8
Liver cancer	1.2 (0.6)	4
Other cancer	25.2 (3.2)	66
Current cancer status		
Yes	42.5 (3.5)	129
No	57.5 (3.5)	160
Comorbidities		
Yes	59.4 (3.4)	172
No	40.6 (3.4)	117
Use of inpatient services within the previous year		
Yes	18.3 (2.6)	60
No	81.7 (2.6)	229
Use of outpatient services within the previous 2 weeks		
Yes	33.7 (3.2)	103
No	66.3 (3.2)	186
Symptom-related problems (range 1-4)†		
Fatigue	2.02 ± 0.05	289
Pain	1.77 ± 0.05	289
Sleep difficulties	1.68 ± 0.05	289
Memory problems	1.66 ± 0.04	289
Depression	1.57 ± 0.04	289
Occupational characteristics		
Current employment status		
Employed	56.6 (3.5)	156
Non-employed	43.4 (3.5)	133
Working hours per week (n = 156)	36.56 ± 1.28	156
Employment type (n = 156)		
Wage worker	76.0 (3.9)	109
Self-employed and employer	20.7 (3.6)	41
Unpaid family worker	3.3 (1.4)	6
Occupational continuity		
Retained longest-held occupation	39.5 (3.4)	104
Current occupation different from longest-held occupation	17.1 (2.4)	52
Currently non-employed with a previous longest-held occupation	41.8 (3.5)	129
Continuously non-employed	1.6 (0.8)	4

Percentages and standard errors are weighted.
†Higher scores indicate greater severity.
KRW = Korean won; M = mean; SE = standard error.

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The mean time since cancer diagnosis was 5.62 years (SE = 0.20). Thyroid cancer was the most common cancer type (33.4%), followed by breast cancer (15.9%). Overall, 42.5% of participants reported currently having cancer, and 59.4% had comorbid conditions. For healthcare utilization, 18.3% had used inpatient services during the previous year, whereas 33.7% had used outpatient services during the previous two weeks. Among the five HINT-8 items assessing symptom-related problems, fatigue had the highest mean score (mean = 2.02).

More than half of the participants were employed (n = 156, 56.6%). Among employed participants, the mean working time was 36.56 hours per week (SE = 1.28), and 76.0% were wage workers. For the correspondence between longest-held and current occupation, 39.5% retained their longest-held occupation, 17.1% had a current occupation that differed from their longest-held occupation, 41.8% were currently non-employed despite having a previous longest-held occupation, and 1.6% were continuously non-employed.

Table 2 presents employment status according to general and clinical characteristics among cancer survivors. Employment status differed significantly by sex, monthly household income, and private insurance coverage ($p < .05$). Male participants were more likely to be employed than female participants (75.1% vs. 48.1%, $p < .001$). Participants with a monthly household income of at least 3 million KRW had a higher employment rate than those with lower income (61.7% vs. 41.6%, $p < .05$). Participants with private insurance also had a higher employment rate than those without private insurance (58.5% vs. 37.0%, $p < .05$). No significant differences in employment status were found by age, education, marital status, household characteristics, time since diagnosis, cancer type, comorbidity, or healthcare utilization.

For the HINT-8 domains, employed participants had significantly lower symptom scores than non-employed participants for pain (1.69 vs. 1.88, $p < .05$), fatigue (1.90 vs. 2.16, $p < .05$), memory problems (1.57 vs. 1.77, $p < .01$), and sleep difficulties (1.58 vs. 1.81, $p < .01$), indicating fewer symptom-related problems.

2. Factors Associated with Employment Status among Cancer Survivors

Hierarchical logistic regression analyses were performed to examine factors associated with employment status among cancer survivors across three models (Table 3). In Model 1, which included sociodemographic factors, sex (odds ratio [OR], 3.37; 95% confidence interval [CI], 1.85–6.15; $p < .001$) and household income (OR, 0.42; 95% CI, 0.20–0.88; $p < .05$) were significantly associated with employment. Male survivors had higher odds of employment than female survivors, whereas participants with a monthly household income below 3 million KRW had lower odds of employment than those with a monthly household income of at least 3 million KRW. Private insurance did not reach statistical significance (OR, 3.00; 95% CI, 0.96–9.37; $p = .058$). In Model 2, after clinical factors were added, sex (OR, 5.06; 95% CI, 2.47–10.40; $p < .001$) and household income (OR, 0.42; 95% CI, 0.20–0.86; $p < .05$) remained significantly associated with employment. None of the clinical factors, including cancer type, time since diagnosis, current cancer status, or comorbidity, were significantly associated with employment. In Model 3, after symptom-related factors were added, sex (OR, 4.69; 95% CI, 2.21–9.94; $p < .001$) and household income (OR, 0.41; 95% CI, 0.19–0.88; $p < .05$) remained significantly associated with employment. Among the symptom-related factors, each 1-point increase in sleep difficulties was associated with lower odds of employment, although this association did not reach statistical significance (OR, 0.64; 95% CI, 0.41–1.00; $p = .051$); pain, fatigue, depression, and memory problems were not significant. Intercorrelations among the five symptom items were low to moderate (r = .21–.42), indicating no evidence of serious multicollinearity (Supplementary Table 2).

3. Sex Differences in Occupational Continuity

Employment rates differed significantly by sex: 75.1% of male participants were employed, compared with 48.1% of female participants ($\chi^2 = 14.06$, $p < .001$). Supplementary Table 3 presents participant characteristics by sex. Significant sex-based differences were observed in head-of-household status, occupational continuity, and pain ($p < .05$). Among male participants, 58.3% retained their longest-held occupation, 16.8% had a current occupation that differed from their longest-held occupation, and 22.9% were currently non-employed despite having a previous longest-held occupation. Among female participants, 30.9% retained their longest-held occupation, 17.2% had a current occupation that differed from their longest-held occupation, and 50.5% were currently non-employed despite having a previous longest-held occupation. Continuously non-employed status was rare in both groups (Figure 1).

Table 2. Employment Status According to General and Clinical Characteristics among Cancer Survivors (N = 289)

Variables	Employed (n = 156)	Non-employed (n = 133)	Adjusted χ^2/t (p)
	M ± SE or unweighted frequency (weighted %)		
Age	51.50 ± 0.81	52.43 ± 1.25	−0.60 (.538)
Sex			14.06 (< .001)
Male	59 (75.1)	25 (24.9)	
Female	97 (48.1)	108 (51.9)	
Education			0.88 (.398)
Less than 12 years of education	24 (49.8)	26 (50.2)	
12 years of education or more	132 (57.7)	107 (42.3)	
Marital status			0.00 (.991)
Married	146 (53.9)	125 (46.1)	
Unmarried	10 (55.6)	8 (44.4)	
Head of household			2.55 (.111)
Yes	90 (62.1)	63 (37.9)	
No	66 (50.7)	70 (49.3)	
Household size			2.18 (.141)
1 or 2	111 (53.9)	105 (46.1)	
3 or more	45 (64.4)	28 (35.6)	
Household income			6.77 (.010)
< 3 million KRW/month	36 (41.6)	50 (58.4)	
≥ 3 million KRW/month	120 (61.7)	83 (38.3)	
Have private insurance			4.46 (.035)
Yes	146 (58.5)	116 (41.5)	
No	10 (37.0)	17 (63.0)	
Time since diagnosis	5.71 ± 0.27	5.50 ± 0.27	0.58 (.563)
Type of cancer			5.24 (.630)
Thyroid cancer	50 (55.9)	42 (44.1)	
Breast cancer	25 (57.0)	24 (43.0)	
Stomach cancer	17 (55.9)	13 (44.1)	
Colon cancer	14 (41.0)	13 (59.0)	
Cervical cancer	6 (46.1)	7 (53.9)	
Lung cancer	3 (44.5)	5 (55.5)	
Liver cancer	2 (54.6)	2 (45.4)	
Other cancer	39 (65.8)	27 (34.2)	
Currently have cancer			1.32 (.252)
Yes	64 (52.1)	65 (47.9)	
No	92 (60.0)	68 (40.0)	
Comorbidities			0.01 (.941)
Yes	92 (56.4)	80 (43.6)	
No	64 (56.9)	53 (43.1)	
Use of inpatient services within the previous year			0.15 (.714)
Yes	31 (59.0)	29 (41.0)	
No	125 (56.1)	104 (43.9)	
Use of outpatient services within the previous 2 weeks			1.18 (.347)
Yes	51 (52.2)	52 (47.8)	
No	105 (58.9)	81 (41.1)	
Symptom-related problems (range 1-4)†			
Fatigue	1.90 ± 0.07	2.16 ± 0.09	−2.18 (.030)
Pain	1.69 ± 0.06	1.88 ± 0.07	−2.04 (.044)
Sleep difficulties	1.58 ± 0.06	1.81 ± 0.07	−2.58 (.009)
Memory problems	1.57 ± 0.05	1.77 ± 0.06	−2.68 (.009)
Depression	1.51 ± 0.05	1.65 ± 0.07	−1.52 (.133)

†Higher scores indicate greater severity.
KRW = Korean won; M = mean; SE = standard error.

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Table 3. Factors Associated with Employment Status among Cancer Survivors: Results of Logistic Regression Analyses (N=289)

Variables	Model 1	Model 2	Model 3
	OR (95% CI)		
Sociodemographic factors			
Age	1.00 (0.96–1.03)	1.00 (0.96–1.04)	1.00 (0.96–1.05)
Sex: male (ref: female)	3.37 (1.85–6.15)**	5.06 (2.47–10.40)**	4.69 (2.21–9.94)**
Education: ≥12 years (ref: <12 years)	1.15 (0.48–2.78)	1.00 (0.43–2.32)	0.99 (0.41–2.39)
Marital status: married (ref: unmarried)	0.97 (0.30–3.14)	0.90 (0.26–3.20)	1.01 (0.29–3.52)
Head of household: yes (ref: no)	0.62 (0.34–1.12)	0.63 (0.34–1.15)	0.61 (0.33–1.12)
Household income <3 million KRW/month (ref: ≥3 million KRW/month)	0.42 (0.20–0.88)*	0.42 (0.20–0.86)*	0.41 (0.19–0.88)*
Household size: 1–2 members (ref: ≥3 members)	0.75 (0.38–1.44)	0.82 (0.41–1.64)	0.75 (0.37–1.53)
Private insurance: yes (ref: no)	3.00 (0.96–9.37)	2.62 (0.80–8.58)	2.75 (0.86–8.72)
Clinical factors			
Time since diagnosis		0.94 (0.76–1.15)	0.91 (0.74–1.11)
Cancer type (ref: other cancer)			
Thyroid cancer		1.13 (0.46–2.74)	1.08 (0.46–2.57)
Breast cancer		1.36 (0.33–5.59)	1.01 (0.25–4.07)
Stomach cancer		0.35 (0.07–1.72)	0.36 (0.07–1.85)
Colon cancer		0.35 (0.08–1.62)	0.30 (0.07–1.32)
Cervical cancer		0.78 (0.12–4.93)	0.71 (0.12–4.31)
Lung cancer		0.63 (0.12–3.40)	0.73 (0.13–4.07)
Liver cancer		0.31 (0.03–3.70)	0.22 (0.02–2.53)
Currently have cancer: yes (ref: no)		1.49 (0.82–2.70)	1.38 (0.77–2.47)
Comorbidities: yes (ref: no)		0.92 (0.48–1.78)	0.84 (0.43–1.65)
Symptom-related factors			
Fatigue			0.89 (0.59–1.34)
Pain			1.16 (0.75–1.81)
Sleep difficulties			0.64 (0.41–1.00)
Memory problems			0.70 (0.41–1.19)
Depression			0.95 (0.56–1.62)
Nagelkerke R^2	.166	.205	.245
Wald F (p)	4.03 (<.001)	2.49 (.001)	2.47 (<.001)

CI=confidence interval; KRW=Korean won; OR=odds ratio; ref=reference category; *p<.05; **p<.001.

DISCUSSION

This study used data from the 2019 and 2021 KNHANES to examine factors associated with current employment status and to describe sex-based differences in occupational continuity among cancer survivors aged 19 to 65 years. More than half of the participants were employed, and employment was associated with sex and household income rather than with available clinical characteristics, including cancer type, current cancer status, time since diagnosis, and comorbidity. Current employment status and occupational continuity did not fully correspond: although 56.6% of participants were employed, only 39.5% remained in the occupation they had held for the longest period, and this discrepancy was more pronounced among women than among men. These findings suggest that, among the variables measured in this study, current employment was more consistently associated with sociodemographic characteristics than with clinical characteristics and that occupational continuity provides information not captured by a binary employment indicator alone.

The employment rate observed in this study (56.6%) was similar to the 54.3% reported in a previous analysis of Korean cancer survivors aged 19 to 60 years using KNHANES data from 2008 to 2018 [27], but higher than the 42.0% reported in an earlier population-based analysis using KNHANES data from 2010 to 2014 [28]. These differences should be interpreted cautiously because the studies dif-

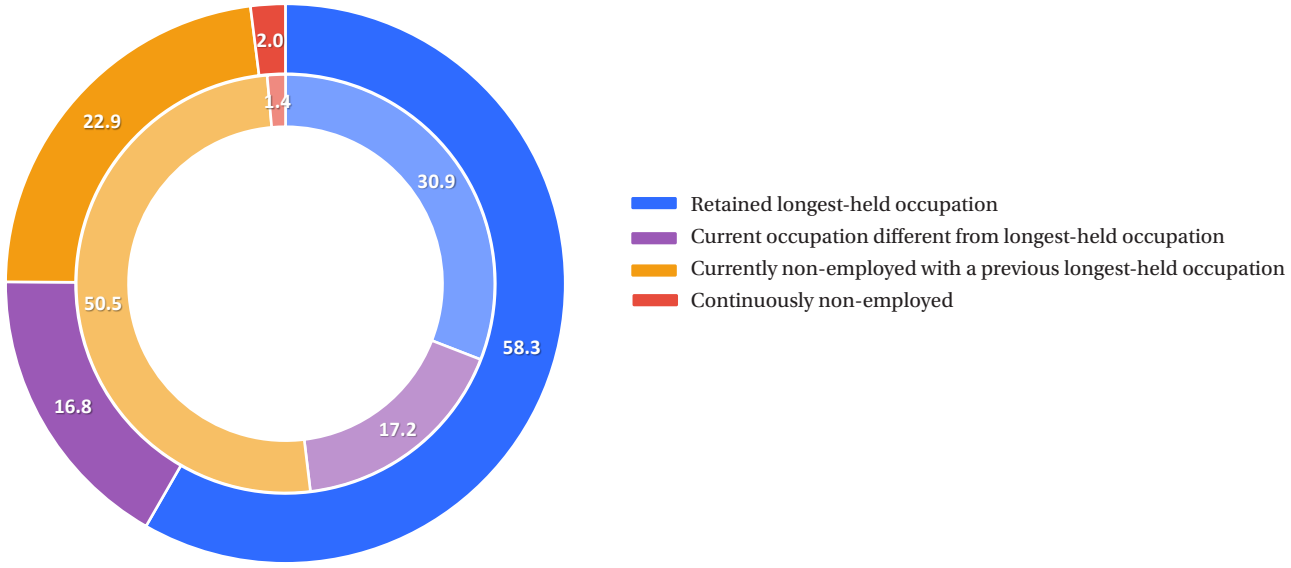

Figure 1. Sex differences in occupational continuity among cancer survivors.
The outer ring represents males (n = 84) and the inner ring represents females (n = 205). Values represent weighted percentages. Data are from the 2019 and 2021 Korea National Health and Nutrition Examination Survey [25,26].

fered in survey years, age restrictions, and sample-selection criteria. Nevertheless, these findings consistently indicate that slightly more than half of working-age Korean cancer survivors participate in the labor market, whereas a substantial proportion remains non-employed. Cancer survivors have also been reported to have a higher risk of unemployment than individuals without a cancer history [29,30].

In addition, 17.1% of participants had a current occupation that differed from their longest-held occupation, and 41.8% were currently non-employed despite having a previous longest-held occupation. These findings suggest that current employment status alone may not adequately describe labor-market participation among cancer survivors and that occupational-continuity patterns should also be considered [22]. However, because KNHANES does not indicate whether the difference between longest-held and current occupation occurred after cancer diagnosis, these results should be interpreted as a cross-sectional distribution of occupational continuity rather than as evidence of a causal postdiagnosis employment trajectory.

Sex-based differences were also observed in occupational continuity. Male participants were more likely than female participants to retain their longest-held occupation, whereas female participants were more likely to be currently non-employed despite having a previous longest-held occupation. This pattern should not be interpreted as a cancer-related employment pathway; rather, it suggests that female cancer survivors may have lower current correspondence between their longest-held and current occupational status. This interpretation is consistent with previous Korean evidence showing sex-based differences in employment disruption and return-to-work outcomes among cancer survivors [23,24].

Male sex was associated with higher odds of current employment in the final model. However, this finding should not be interpreted as evidence that sex itself causally determines employment status or occupational continuity. In the Korean labor market, women may face structural vulnerabilities, including career discontinuity, concentration in non-regular employment, and disproportionate caregiving responsibilities, even before a cancer diagnosis [24]. In the present study, female participants had a lower employment rate and lower current correspondence between longest-held and current occupational status than male participants. These findings support the need for sex-sensitive assessment and vocational support, while recognizing that unmeasured factors, such as caregiving roles, employment type, workplace support, and prediagnosis employment history, may also contribute to the observed differences.

Lower household income remained associated with lower odds of employment in the final model, suggesting that labor-market participation among cancer survivors is embedded in broader socioeconomic conditions rather than being solely a health-related issue [31]. Cancer survivors with lower household incomes may experience greater financial burden during and after treatment and may have

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more limited access to resources that support continued employment or reemployment, including education, social networks, and flexible work arrangements [32]. However, because this study was cross-sectional, the direction of the relationship between household income and employment status cannot be determined. Employment support for cancer survivors should therefore consider socioeconomic vulnerability alongside health-related needs.

Although sleep difficulties were not statistically significant in the final model, sleep problems remain clinically relevant in cancer survivorship and may affect daily functioning and survivorship care needs [33,34]. Sleep quality should therefore be interpreted as a supportive assessment domain rather than as an independent factor associated with employment in this study.

Clinical variables included in the final model, such as cancer type, time since diagnosis, current cancer status, and comorbidity, were not significantly associated with employment. This finding should not be interpreted as evidence that clinical factors are irrelevant. More detailed clinical and occupational variables, including cancer stage, treatment modality, treatment-related adverse effects, workplace environment, and physical job demands, were not available in the KNHANES dataset; therefore, the clinical impact of cancer may not have been fully captured [35]. In this community-based sample of long-term cancer survivors, the more consistent associations were observed for sex and household income, suggesting that employment status should be understood in both health-related and socioeconomic contexts.

The findings of this study have several implications for survivorship nursing practice. First, assessment of employment status among cancer survivors should include not only whether survivors are currently employed or non-employed but also their occupational-continuity patterns. Second, vocational counseling and referral should consider sex and socioeconomic context because employment was associated with both sex and household income. Third, although sleep difficulties were not statistically significant in the final model, sleep quality may be assessed as part of comprehensive survivorship care, together with fatigue, cognitive concerns, daily functioning, and work-related difficulties. These implications should be understood as exploratory and supportive rather than as evidence of causal effects on employment status [36].

A strength of this study is that it used nationally representative KNHANES data with complex-sampling analyses; however, several limitations should be noted. First, the cross-sectional design precludes causal inference, and because KNHANES does not collect employment history before cancer diagnosis, current employment status could not be linked to a prediagnosis baseline or assumed to reflect a return-to-work trajectory after cancer diagnosis. Second, employment status was operationalized as a binary outcome and did not capture qualitative aspects of labor participation, such as full-time versus part-time work, sick leave, or reduced work intensity. In addition, each symptom was measured using a single HINT-8 item rather than a multi-item scale, which prevented assessment of internal consistency and may have captured a narrower aspect of each symptom than validated multi-item instruments; therefore, both the employment and symptom-related findings should be interpreted with caution. Third, the discrepancy between longest-held and current occupations cannot be assumed to have occurred after cancer diagnosis; therefore, occupational continuity should be interpreted as a current status distribution rather than as a causal employment trajectory. Fourth, key variables such as cancer stage, treatment modality, treatment-related adverse effects, workplace environment, and physical job demands were unavailable in the dataset, and the clinical impact of cancer may therefore not have been fully captured. Fifth, the full model included 156 employed events across 23 non-intercept parameters, corresponding to approximately 6.8 events per parameter, and some cancer types included very few cases (e.g., four participants with liver cancer); therefore, the ORs for these subcategories were estimated with wide CIs and should be interpreted cautiously. Sixth, the overrepresentation of females and thyroid cancer survivors warrants caution when generalizing the results. Finally, sex-based differences in this study were examined primarily through descriptive analyses. Given the limited number of male survivors (n=84), sex-stratified regression and sex-by-symptom interaction models could not be estimated with adequate stability and therefore were not conducted.

Future studies with larger samples should use longitudinal designs and adequately powered sex-stratified or interaction analyses to clarify changes in employment status and occupational continuity after cancer diagnosis. Such studies should also incorporate cancer stage and treatment characteristics and determine whether factors associated with employment differ by sex.

CONCLUSION

This study found that current employment status among cancer survivors aged 19 to 65 years was associated with sex and household income, whereas sleep difficulties showed a possible association that did not reach statistical significance. Although 56.6% of participants were employed, only 39.5% retained their longest-held occupation, and 41.8% were currently non-employed despite having a previous longest-held occupation. These findings suggest that labor-market participation among cancer survivors should be understood not only in terms of current employment status but also in relation to occupational continuity.

Based on these findings, survivorship care should include assessment of current employment status, occupational continuity, and socioeconomic context. Sleep quality may also be assessed as part of comprehensive survivorship care, although its association with employment was not statistically significant in the final model. Future longitudinal studies are needed to clarify changes in employment status and occupational continuity after cancer diagnosis.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - BH; data curation and analysis - BH; interpretation of the data - BH and SKK; and drafting or critical revision of the manuscript for important intellectual content - BH, SKK, and SJP.

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DATA AVAILABILITY STATEMENT

The data used in this study are publicly available from the Korea National Health and Nutrition Examination Survey website (https://knhanes.kdca.go.kr). No new data were generated in this study.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2026.0514_2.

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Mapping Health Literacy Research in Korea: A Keyword Network and Topic Modeling Analysis

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Purpose: This study examined the knowledge structure and thematic characteristics of health literacy research in Korea through keyword network analysis and topic modeling. **Methods:** Keyword frequency and co-occurrence network analyses included 637 articles. For latent Dirichlet allocation, English abstracts were combined with standardized author keywords. After preprocessing and document-frequency filtering, 636 articles remained in the effective latent Dirichlet allocation corpus. Models with 3–10 topics were evaluated across 10 random seeds according to log-likelihood, perplexity, semantic coherence, topic distinctiveness, cross-seed stability, and interpretability of representative documents. A five-topic solution was selected, and the final model was estimated using seed 2026. An abstract-only sensitivity analysis was conducted with 633 articles. **Results:** Health literacy occupied the most central position in the network, as expected because it was the core search concept. Among the remaining keywords, older adults, eHealth literacy, self-efficacy, health behavior, and self-care had the highest degree centrality. Louvain clustering identified six thematic communities. The five latent Dirichlet allocation topics were Health Literacy Measurement, Mental Health Literacy, Health Information and Communication, Digital Health Literacy, and Disease-Specific Health Literacy. Topic prevalence ranged from 17.1% to 21.4%. Disease-Specific Health Literacy was the largest topic (21.4%, n = 136), followed by Digital Health Literacy (21.2%, n = 135) and Mental Health Literacy (21.1%, n = 134). The sensitivity analysis produced a broadly comparable five-topic structure. **Conclusion:** This study systematically mapped the knowledge structure of Korean health literacy research. The findings shed light on major research themes and their relationships and may help inform future research priorities.

Key Words: Health literacy; Korea; Social network analysis; Natural language processing; Health communication

INTRODUCTION

Health literacy is a major determinant of health outcomes and health equity because it affects how individuals access, understand, evaluate, and apply health information when making decisions [1-4]. In patients with chronic conditions, health literacy is associated with treatment adherence, self-care, and disease management outcomes [5-7]. Limited health literacy has been linked to poor medication adherence, increased hospitalization, and adverse health outcomes, particularly among older adults and other vulnerable populations [7-9]. Higher health literacy, by con-

trast, is associated with better self-management, higher quality of life, and more effective engagement with health care systems [10,11].

Health literacy includes basic functional skills but also extends to broader competencies, such as digital health literacy, eHealth literacy, organizational health literacy, and critical health literacy [12-14]. This expanded scope reflects the increasing complexity of health care environments and the growing use of digital technologies to obtain and manage health information. As the concept has broadened, numerous studies have synthesized and conceptualized the field through systematic reviews and conceptual analyses [14-16].

In Korea, health literacy research has addressed health information comprehension, health behaviors, health care utilization, chronic disease self-management, and health inequities across diverse populations, including older adults, people with chronic diseases, and other vulnerable groups [17,18]. Recent studies have also examined digital health literacy, health information accessibility, and strategies for reducing health disparities [19,20].

Despite this breadth, few studies have systematically examined the knowledge structure of health literacy research in Korea, including its major thematic domains and the relationships among research topics. Korean studies have reviewed health literacy research trends and policy implications [18] and have used topic modeling to identify major themes in domestic health literacy research [21]. However, these studies have not comprehensively examined the intellectual structure of the field or the interrelationships among research themes through an integrated approach combining keyword network analysis and topic modeling.

International studies have used bibliometric analysis, keyword network analysis, and topic modeling to examine the knowledge structure and thematic patterns of health literacy research [22,23]. By analyzing large-scale textual data, these approaches can identify major research themes and clarify how they are related [24,25]. However, most existing analyses have focused on English-language publications indexed in international databases. Such studies may not adequately capture the health care system, policy context, or sociocultural characteristics that shape Korean health literacy research. Because health literacy is strongly influenced by health care systems and sociocultural environments [1,4], findings from international literature may not fully represent the distinctive features of the Korean context.

A comprehensive analysis of literature indexed in the Korean Citation Index (KCI) is therefore needed to characterize the knowledge structure and major thematic domains of health literacy research in Korea. This study used keyword network analysis and topic modeling to examine health literacy-related articles published in KCI-indexed journals. Specifically, it examined structural relationships among keywords, identified major research themes, and characterized the knowledge structure of Korean health literacy research. By mapping the intellectual landscape of this field, the study may help identify research gaps and inform evidence-based directions for future scholarship and policy development.

METHODS

1. Study Design

This text-mining study characterized the current landscape of health literacy research in Korea. Word cloud analysis, keyword network analysis, and topic modeling were used to identify major research themes and latent topic structures.

2. Data Sources and Search Strategy

Relevant literature was retrieved from the KCI, a national database of peer-reviewed academic journals published in Korea. Searches were conducted with the KCI “All Fields” option to identify health literacy-related research in Korea as comprehensively as possible. Four Korean search terms related to health literacy were searched separately: “건강문해력” (health literacy), “건강정보이해” (understanding of health information), “건강정보활용” (use of health information), and “헬스 리터러시” (health literacy). The number of records retrieved for each search term is shown in Supplementary Figure 1. The initial searches were conducted on April 16, 2026, and an additional search was conducted on June 1, 2026, to capture newly indexed publications. Publication year was not restricted; therefore, all records indexed in KCI from database inception through June 1, 2026, were eligible for screening.

The search identified 1,235 records. Records retrieved from multiple searches were merged into a single dataset, and duplicates were removed using article title, author names, publication year, and journal title. After 401 duplicate records were removed, 834 unique articles remained for screening.

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Two researchers independently reviewed titles, abstracts, and author-provided keywords to assess eligibility. Discrepancies in study selection were resolved through discussion and consensus. Studies were included when health literacy was a major focus, including studies of its measurement, determinants, outcomes, interventions, or conceptual development.

Studies were excluded when (1) health literacy was mentioned only incidentally and was not a major focus; (2) relevance to health literacy could not be determined from the title, abstract, or keywords; or (3) the publication was not an original scholarly article, such as an editorial, announcement, conference notice, or other nonacademic material.

After title, abstract, and keyword screening, 197 articles were excluded, yielding a final study dataset of 637 articles. All 637 articles were retained for keyword-based analyses because standardized author-provided keywords were available. Four articles lacked usable English abstracts, but their standardized author keywords were retained for construction of the combined latent Dirichlet allocation (LDA) corpus. After preprocessing and document-frequency filtering, one of these keyword-only records contained no retained terms; therefore, the effective LDA corpus included 636 articles. The overall study selection process is shown in Supplementary Figure 1.

3. Data Preprocessing

For keyword-based analyses, author-provided keywords were cleaned and standardized in four steps. First, keywords were separated into individual units using comma delimiters. Second, duplicate keywords were removed. Third, synonymous expressions and spelling variants were standardized with a customized thesaurus developed through iterative review. Two researchers independently reviewed the thesaurus, and discrepancies were resolved through discussion and consensus. Examples of standardized variants included "self care" and "self-care," "eHealth literacy" and "e-health literacy," and "elderly," "older people," and "older adults." Related Health Literacy Survey instrument terms, including HLS-EU, HLS-Q12, and HLS-SF12, were standardized under the umbrella term "HLS." Fourth, differences in capitalization and spelling were harmonized across records.

Closely related terms were standardized, but conceptually distinct terms were kept as separate keywords. For example, *self-care* and *self-management* were not merged because *self-management* is considered a distinct dimension of *self-care* in chronic disease management.

For topic modeling, additional normalization procedures were used to preserve multiword concepts during tokenization. Frequently occurring multiword terms identified during thesaurus development were converted into single lexical units with underscore notation, including "self efficacy" → "self_efficacy," "quality of life" → "quality_of_life," and "older adults" → "older_adults." Standardized author keywords were then merged with the corresponding English abstracts using a unique article identifier. This unified corpus was designed to represent both author-defined research themes and the substantive content of the publications.

The corpus was then preprocessed by lowercasing text, removing punctuation and noninformative characters, and applying a customized stop-word dictionary. The stopword list was refined during preliminary model development and finalized before the sensitivity and stability analyses. Non-substantive reporting and methodological terms identified during this process—including confirmed, mediation_analysis, t_test, correlated, review, and similar generic descriptors—were removed along with standalone numeric expressions. Terms were retained when they could convey substantive meaning in the health literacy literature. The final preprocessing specification was frozen and applied consistently to the full and abstract-only corpora.

4. Keyword Frequency and Word Cloud Analysis

Keyword frequency analysis was performed using the standardized author-provided keyword dataset to identify the most frequently occurring terms in the health literacy literature. A word cloud was then generated from the frequency distribution to visually summarize the relative prominence of keywords.

Because health literacy was the primary search term used to identify the literature and overwhelmingly dominated the frequency distribution, it was excluded from the word cloud to make secondary research themes more visible. Keywords appearing fewer than two times were excluded, and the 100 most frequent remaining keywords were retained to improve interpretability. The resulting word cloud showed the relative prominence of key concepts within the field.

5. Keyword Network Analysis

Keyword network analysis was performed using standardized author-provided keywords. For each article, unique keywords were identified, and all possible keyword pairs were generated to construct a weighted, undirected document-level co-occurrence network. In this network, nodes represented keywords, edges represented co-occurrence within the same article, and edge weights indicated how often keyword pairs co-occurred across articles.

To improve interpretability and reduce network sparsity, only keyword pairs with a co-occurrence frequency of three or greater were retained. After network construction, nodes with fewer than two connections were removed from the final visualization. Node size was categorized by keyword frequency (<10, 10–19, 20–49, 50–99, and ≥100 occurrences), edge width represented co-occurrence strength, and node color indicated communities identified through Louvain community detection.

Community structure was identified by applying the Louvain community detection algorithm [26] to the final weighted keyword co-occurrence network, with edge weights representing co-occurrence frequencies. A random seed of 2026 was set before community detection to ensure reproducibility. The modularity statistic was calculated to assess the strength of the resulting community structure. Figure 2 and Supplementary Table 1 were generated from the same final network object and identical Louvain community membership.

Network centrality measures—including degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality—were calculated from the same final keyword co-occurrence network to identify structurally prominent keywords and examine their roles within the network. Degree centrality was calculated as the unnormalized number of direct connections between a keyword and other keywords. Betweenness centrality reflected the extent to which a keyword bridged different parts of the network, whereas closeness centrality indicated its proximity to all other keywords; both measures were calculated using the normalized options implemented in the igraph package. Eigenvector centrality reflected the relative importance of a keyword based on its connections to other highly connected keywords and was calculated using eigen_centrality() in the igraph package [27].

6. Topic Modeling

Topic modeling was performed using LDA [28] to identify latent thematic structures in Korean health literacy research. A document-term matrix was constructed from the preprocessed corpus and used as the input for LDA modeling.

To determine the topic structure, LDA models with 3–10 topics were estimated using Gibbs sampling [29] implemented in the topicmodels package in R. Candidate solutions were evaluated across 10 random seeds. The burn-in period was 1,000 iterations, the number of sampling iterations was 3,000, and the thinning interval was 100. Dirichlet priors were set to $\alpha = 50/k$ and $\beta = .1$ [29]. For the selected five-topic model ($k = 5$), this specification corresponded to a symmetric α parameter of 10 for each topic. Model selection considered log-likelihood, perplexity, semantic coherence of high-probability terms, topic distinctiveness, cross-seed stability based on one-to-one matching of topic-specific top terms, and substantive interpretability. Because statistical fit improved monotonically as k increased, the final solution was not selected on the basis of minimum perplexity alone. Models adjacent to the selected solution were also examined for topic merging and fragmentation. After $k = 5$ was selected, the final model was estimated with a fixed random seed of 2026 for reproducibility.

Topic interpretation was based on the terms with the highest β values and the 10 documents with the highest posterior probabilities (γ) for each topic. Preliminary labels were assigned according to the dominant concepts represented in both sources. Two researchers independently reviewed the labels and representative documents, and discrepancies were resolved through discussion and consensus.

7. Statistical Analysis and Visualization

All analyses were conducted using R software (version 4.5.2, R Foundation for Statistical Computing, Vienna, Austria). Data preprocessing and text-mining procedures were performed using the tidyverse and tidytext packages. Topic modeling was conducted using the topicmodels package. Keyword network analyses, including centrality-measure calculation and community detection, were performed using the igraph package, whereas network visualizations were generated using ggraph. Visualization outputs included word clouds, keyword co-occurrence networks, topic-term plots, and topic-distribution bar charts.

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8. Ethical Considerations

This study analyzed publicly available bibliographic data and did not involve human participants. The Institutional Review Board (IRB) of Samsung Medical Center advised that the study was not subject to IRB review because it used only publicly available bibliographic data.

RESULTS

1. Word Cloud for Keywords

A word cloud was generated to summarize the most frequently occurring author-provided keywords across the included studies (Figure 1). Because health literacy was the most frequent keyword and dominated the visualization, it was excluded from the word cloud to improve the interpretability of the remaining terms. After health literacy was excluded, the most frequent keywords were "older adults," "eHealth literacy," "health behavior," "self-efficacy," "social support," and "mental health literacy" (Table 1). Other frequent terms included "self-care," "health promotion," "diabetes mellitus," "quality of life," and "nursing students."

2. Keyword Co-occurrence Network Analysis

Figure 2 shows the keyword co-occurrence network constructed from standardized author-provided keywords. As expected, health literacy occupied the most central position in the network, with the highest degree centrality (49), betweenness centrality (.731), closeness centrality (.929), and eigenvector centrality (1.000). Because health literacy was the core search concept used to identify the literature, this dominant position should be interpreted as a feature of the search strategy rather than as an independent substantive finding. Other prominent keywords included older adults, eHealth literacy, self-efficacy, health behavior, and self-care.

Community detection using the Louvain algorithm identified six keyword clusters (modularity = .191). Cluster 1 represented aging, chronic disease, and health management; Cluster 2, eHealth literacy, health information, and health promotion; Cluster 3, general and population-based health literacy; Cluster 4, digital and mental health literacy with psychosocial factors; Cluster 5, oral health literacy; and Cluster 6, clinical competence and patient-centered care. Representative keywords and the thematic interpretation of each cluster are shown in Supplementary Table 1.

Figure 1. Word cloud of author-provided keywords after exclusion of "health literacy."
Word size is proportional to keyword frequency.

Table 1. Centrality Measures for the Top 20 Keywords in the Health Literacy Network

Rank	Keyword	Degree	Betweenness	Closeness	Eigenvector	Frequency
1	Health literacy	49	.731	.929	1.000	436
2	Older adults	23	.076	.627	.659	100
3	eHealth literacy	17	.095	.598	.514	63
4	Self-efficacy	12	.009	.553	.491	41
5	Health behavior	11	.014	.547	.401	51
6	Self-care	10	.006	.531	.383	32
7	Social support	9	.007	.536	.375	35
8	Nursing students	9	.006	.536	.338	28
9	Health promotion	8	.004	.531	.342	31
10	Diabetes mellitus	8	.002	.520	.334	31
11	Quality of life	7	.001	.515	.326	30
12	Literacy	6	.003	.510	.162	25
13	Knowledge	6	.001	.510	.284	24
14	Digital health literacy	6	.002	.510	.267	23
15	Health promotion behavior	6	.001	.520	.272	21
16	Mental health literacy	5	.002	.505	.186	35
17	Health information	5	.000	.515	.225	18
18	Oral health	5	.002	.505	.169	16
19	Hypertension	5	.000	.505	.239	15
20	Digital health	4	.000	.510	.230	20

Betweenness = bridging role between keywords; Closeness = proximity to other keywords in the network; Degree = number of direct connections; Eigenvector = influence based on connections to highly connected keywords.

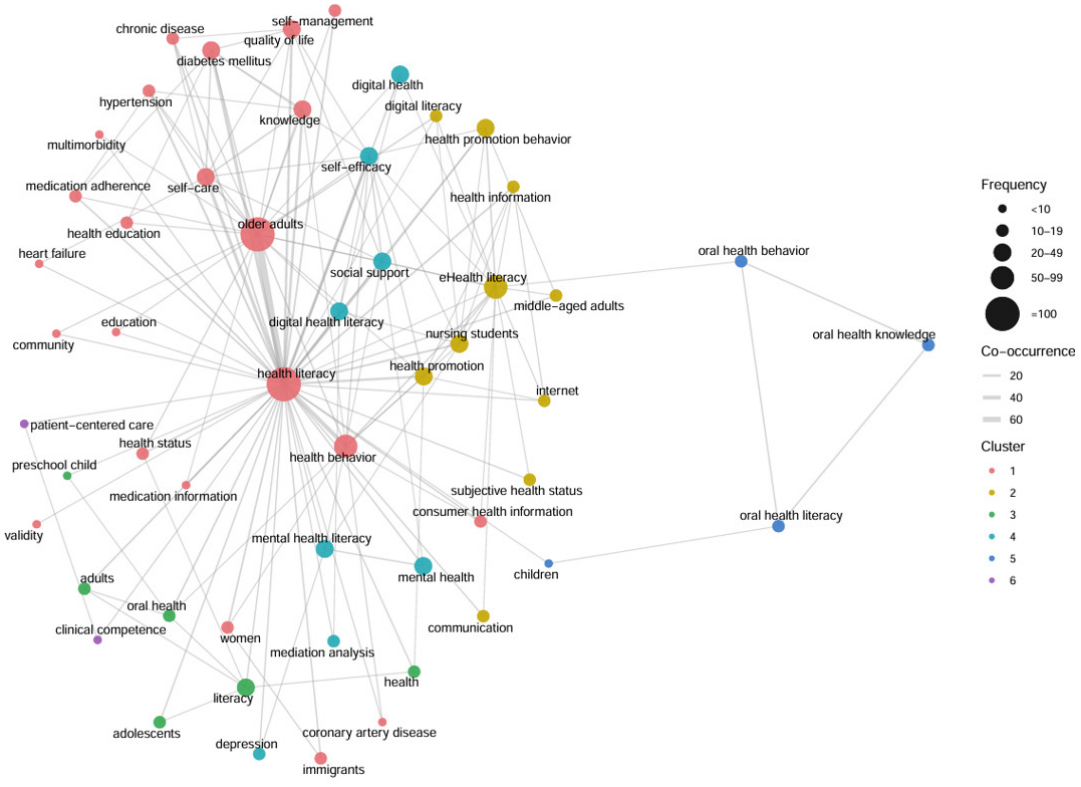

Figure 2. Keyword co-occurrence network and Louvain community structure of Korean health literacy research.
Node size represents categorized keyword frequency (<10, 10–19, 20–49, 50–99, and ≥100 occurrences), node color represents Louvain community membership, and edge width represents keyword co-occurrence frequency. The thematic interpretation of each cluster is presented in Supplementary Table 1.

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The supplementary network that excluded health literacy provided a clearer view of co-occurrence relationships among the remaining keywords, with older adults and eHealth literacy appearing visually prominent (Supplementary Figure 2). After health literacy was removed, the major thematic groupings remained visually identifiable, allowing relationships among secondary research concepts to be examined without the dominance of the core search term. Table 1 further characterizes the structural importance of individual keywords by presenting centrality measures for the top 20 keywords. Consistent with the search strategy, health literacy had the highest values across all centrality measures. Among the remaining keywords, older adults, eHealth literacy, self-efficacy, health behavior, and self-care had the highest degree centrality, indicating their prominence within the secondary keyword structure.

3. Topic Modeling

1) Topic model selection

LDA models with 3–10 topics were compared using model-fit indices, semantic coherence, topic distinctiveness, cross-seed stability, and substantive interpretability (Supplementary Table 2). Across 10 random seeds, mean perplexity decreased from 516 at k=3 to 399 at k=10, whereas semantic coherence and cross-seed stability did not improve monotonically as k increased. Mean cross-seed stability was .488 at k=3, .445 at k=5, and .464 at k=6, and it declined for most higher-dimensional solutions. Inspection of adjacent solutions indicated that k=3 merged substantively distinct domains, whereas k=6 and higher increasingly subdivided related themes. Taken together, these criteria supported selection of the five-topic model as a parsimonious and interpretable thematic solution. The abstract-only sensitivity corpus (N=633) showed a broadly comparable model-fit trajectory (Supplementary Figure 3).

2) Identification and interpretation of topics

The five-topic model identified five major thematic domains in Korean health literacy research. Topic interpretation was based on the highest-probability terms and review of the 10 documents with the highest posterior probabilities for each topic.

Topic 1, Health Literacy Measurement, represented studies assessing and measuring health literacy across diverse populations. High-probability terms included “education,” “adults,” “age,” “women,” “students,” “lower,” “school,” “income,” “children,” and “functional health literacy.” Review of the 10 documents with the highest posterior probabilities showed a strong concentration of instrument development, reliability and validity testing, cross-cultural adaptation, and population-specific health literacy assessment, supporting the topic label.

Topic 2, Mental Health Literacy, centered on mental health literacy and related psychosocial and health-status factors. High-probability terms included “older adults,” “mental health,” “status,” “social support,” “mental health literacy,” “community,” “quality of life,” “middle,” “chronic disease,” and “cancer.” Representative documents addressed depression, suicide literacy, stigma, help-seeking, social support, and psychological well-being in various population groups.

Topic 3, Health Information and Communication, encompassed research on access to, use of, and communication of health and medical information. High-probability terms included “information,” “health information,” “medical,” “healthcare,” “social,” “digital,” “ability,” “service,” “public,” and “communication.” Representative documents addressed health-information seeking, information channels and services, personal health information, communication, and related policy or conceptual issues.

Topic 4, Digital Health Literacy, represented studies linking eHealth and digital health literacy with health behaviors and health-promotion contexts. High-probability terms included “eHealth literacy,” “health behavior,” “efficacy,” “health promotion behavior,” “physical activity,” “digital health literacy,” “positive,” “perceived,” “behaviors,” and “nursing students.” Representative documents frequently involved nursing or university students and examined digital information use, health-promoting behavior, and related competencies.

Topic 5, Disease-Specific Health Literacy, focused on applications of health literacy to patient care, disease-specific knowledge, education, and self-management. High-probability terms included “care,” “patients,” “knowledge,” “oral health,” “oral health literacy,” “diabetes mellitus,” “education,” “management,” “intervention,” and “educational.” Representative documents addressed oral health, diabetes, hypertension, stroke, heart failure, and other disease-specific care contexts, supporting interpretation of this topic as broader disease-specific health literacy rather than oral health literacy alone.

Figure 3 shows the 10 terms with the highest topic-word probabilities (β) for each topic, using reader-friendly labels rather than tokenized forms. The refined preprocessing

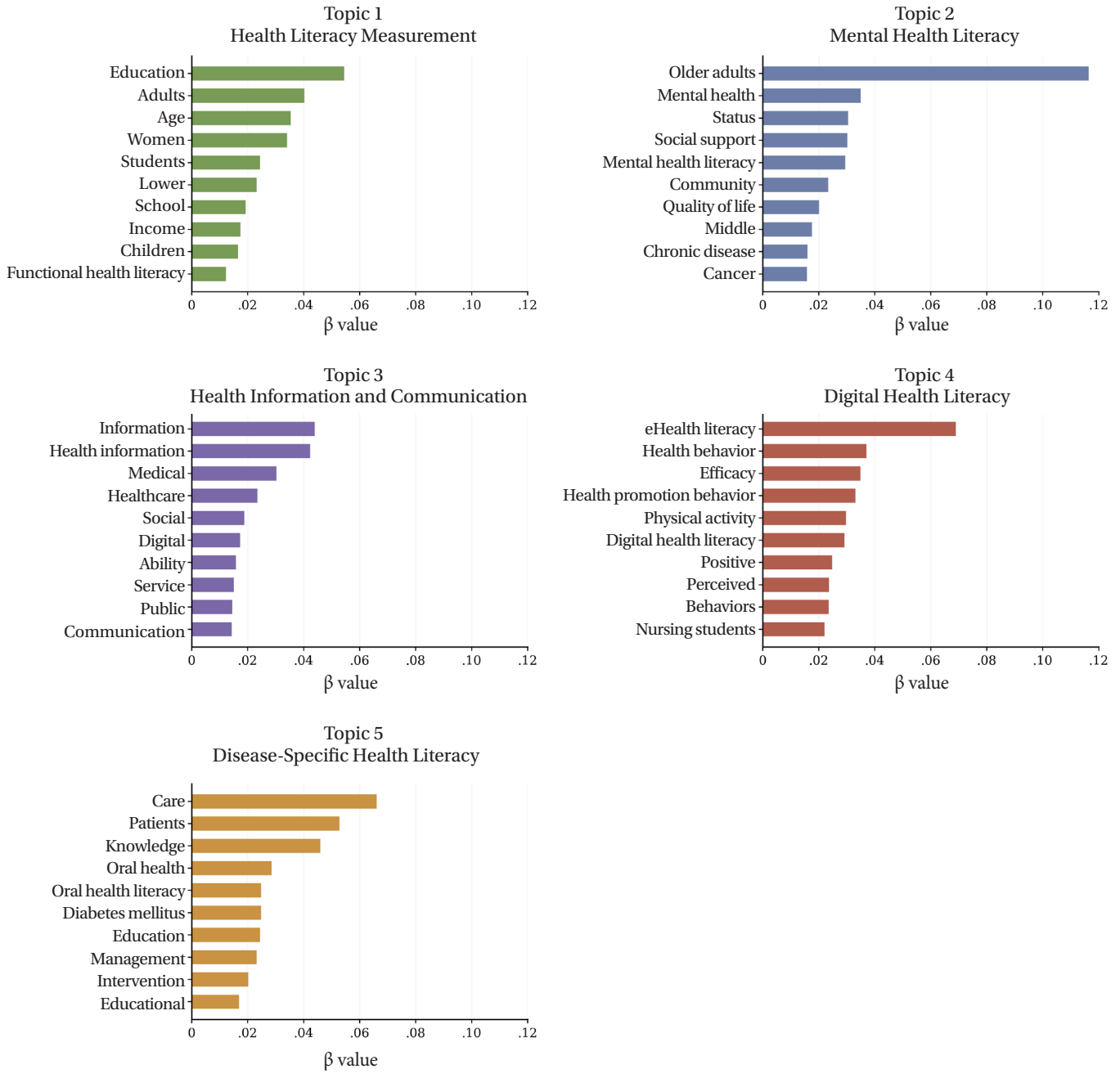

Figure 3. Top 10 terms for each topic identified by the final five-topic latent Dirichlet allocation model.
Bar lengths represent topic-word probabilities (β). Display labels were converted from tokenized forms to reader-friendly terms. Topic labels were assigned based on the highest-probability terms and review of the 10 documents with the highest posterior topic probability for each topic.

step removed non-substantive methodological and reporting terms. Overall, the five topics represented health literacy measurement, mental health literacy, health information and communication, digital health literacy, and disease-specific health literacy.

3) Topic prevalence

Figure 4 shows the dominant-topic distribution for the effective full LDA corpus (N=636). Disease-Specific Health Literacy (topic 5) was the largest topic, accounting for 21.4% of documents (n=136), followed closely by Digital Health Literacy (topic 4; 21.2%, n=135) and Mental Health

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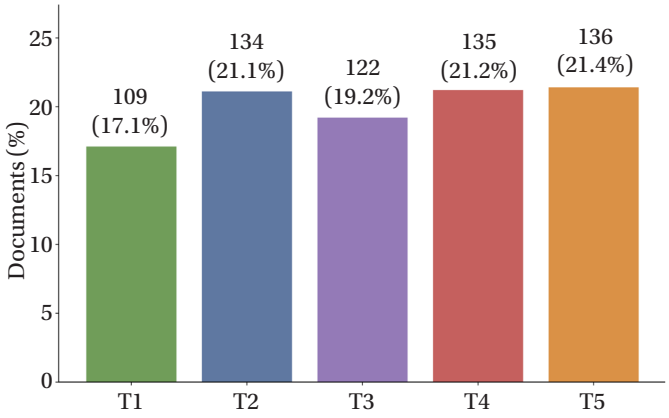

Figure 4. Distribution of documents across the five latent topics in the effective full latent Dirichlet allocation corpus (*N* = 636). Percentages represent the proportion of documents assigned to the dominant topic based on the highest posterior probability (γ). T1 = Health Literacy Measurement; T2 = Mental Health Literacy; T3 = Health Information and Communication; T4 = Digital Health Literacy; T5 = Disease-Specific Health Literacy.

Literacy (topic 2; 21.1%, n = 134). Health Information and Communication (topic 3) accounted for 19.2% of documents (n = 122), and Health Literacy Measurement (topic 1) accounted for 17.1% (n = 109). The five topics were relatively evenly distributed, with no single domain dominating the corpus.

DISCUSSION

This study used keyword analysis, network analysis, and topic modeling to examine the knowledge structure and thematic characteristics of health literacy research in Korea. Together, the findings characterize the major themes, keyword relationships, and latent topic structure of this research field.

First, the diversity of frequently occurring keywords indicates that health literacy research in Korea extends beyond basic health information comprehension to include older populations, digital health contexts, psychosocial determinants, and health-related outcomes. This pattern is consistent with contemporary conceptualizations of health literacy as a multidimensional construct that integrates the cognitive, social, and behavioral competencies needed for effective health management [1,4]. The prominence of self-efficacy and social support further suggests that Korean health literacy research has emphasized patient empowerment and social determinants of health, both of which are important for health outcomes and self-management [5,30]. Overall, these findings indicate that Korean health literacy research treats health literacy not merely as the ability to understand health information but as a resource shaped by individual capabilities and social contexts.

Second, keyword network analysis showed that health literacy occupied a central position in the research landscape and was connected with health behavior, health promotion, chronic disease management, and psychosocial constructs. Its close associations with chronic disease-related keywords, such as diabetes mellitus and hypertension, are consistent with evidence that health literacy is relevant to self-care, treatment adherence, and disease management [7,9]. Because health literacy was the core search concept, its hub-like position should be interpreted cautiously. Even so, the network demonstrated meaningful links between health literacy and behavioral, clinical, and psychosocial constructs.

The presence of quality of life and social support among the top 20 keywords in the centrality analysis further underscores their relevance within the Korean health literacy research landscape and is consistent with evidence linking health literacy to quality of life [11,31]. These findings also fit socioecological perspectives that conceptualize health literacy as operating within interpersonal and community contexts rather than solely as an individual characteristic [1,4]. Similar patterns were observed in the supplementary network excluding health literacy, where older adults, self-efficacy, eHealth literacy, and social support remained visually prominent (Supplementary Figure 2). This supplementary analysis allowed secondary keyword relationships to be examined without the visual dominance of the core search term.

Third, topic modeling identified five complementary domains: Health Literacy Measurement, Mental Health Literacy, Health Information and Communication, Digital Health Literacy and Disease-Specific Health Literacy. The relatively even topic prevalence (17.1%–21.4%) suggests that Korean health literacy research is distributed across multiple methodological and substantive domains rather than concentrated in a single area. Review of the representative documents further supported the conceptual separation of these five domains.

The Health Literacy Measurement topic highlights the methodological foundation of the literature. The documents with the highest posterior probabilities were concentrated in instrument development, psychometric evalu-

ation, cross-cultural adaptation, and population-specific assessment. This finding indicates sustained attention in Korean health literacy research to how health literacy is operationalized and measured across diverse populations, which is a prerequisite for valid comparison and intervention evaluation.

Mental Health Literacy and Digital Health Literacy emerged as distinct substantive domains. Documents representing the mental health topic addressed depression, suicide literacy, stigma, help-seeking, social support, and psychological well-being, underscoring the relevance of mental health literacy to community-based health literacy research [32]. The digital health topic linked eHealth and digital health literacy with health behaviors, health promotion, and student populations. This pattern is consistent with evidence that digital health literacy contributes to effective engagement with technology-mediated health information and services [12,19,33-35].

Health Information and Communication formed a separate domain centered on information access, information seeking, services, and health care communication, reflecting the information-navigation dimension of health literacy. Disease-Specific Health Literacy, the largest topic by a small margin, encompassed patient care, disease-related knowledge, education, oral health, diabetes, and self-management. The inclusion of oral health terms within this broader disease-specific topic helps explain the relatively peripheral position of individual oral-health keywords in the co-occurrence network. The keyword network captured pairwise relationships among author-provided keywords, whereas LDA identified document-level latent semantic patterns from the combined abstract-and-keyword corpus. Thus, oral health is best interpreted as one component of a broader disease-specific health literacy domain rather than as an independent dominant topic [7,9].

Taken together, these findings indicate that Korean health literacy research includes methodological development as well as psychosocial, informational, digital, and disease-specific applications. The relatively even thematic distribution suggests the need for context-specific strategies across multiple domains rather than a focus on a single area. For nursing practice and education, the findings point to the importance of valid health literacy assessment, effective health communication, digital health literacy, mental health literacy, and disease-specific self-management support across diverse populations.

A major strength of this study is its integration of keyword-based analyses with topic modeling based on combined abstracts and standardized author keywords. The large corpus of KCI-indexed studies further strengthens the comprehensiveness of the findings within the KCI-indexed literature. Nevertheless, several limitations should be acknowledged. First, the study relied exclusively on KCI-indexed publications; therefore, relevant studies indexed in international databases or published in nonindexed domestic sources may not have been captured. Second, the analyses used abstracts and standardized author keywords rather than full-text articles, which may have limited the depth and contextual richness of thematic extraction. Third, the findings may have been affected by preprocessing decisions, including stop-word selection, keyword standardization, thesaurus development, and document-frequency filtering. To address this concern, the preprocessing specification was finalized before sensitivity analysis and applied consistently across corpora. Fourth, topic-model selection remains inherently uncertain: log-likelihood and perplexity improved monotonically as k increased, so the five-topic solution was selected using these statistics together with semantic coherence, topic distinctiveness, cross-seed stability, and representative-document interpretability. The abstract-only sensitivity analysis yielded a broadly comparable five-topic structure, supporting the selected thematic configuration, although uncertainty remains.

Future studies that incorporate full-text analyses, additional domestic and international databases, and longitudinal designs may provide a more detailed understanding of how health literacy research in Korea has evolved. Such work may help identify emerging research priorities and support the development of evidence-based health literacy interventions and policies.

CONCLUSION

This study mapped the knowledge structure of Korean health literacy research by integrating keyword network analysis and topic modeling. The final five-topic solution identified Health Literacy Measurement, Mental Health Literacy, Health Information and Communication, Digital Health Literacy, and Disease-Specific Health Literacy as the major thematic domains, with a relatively even distribution across the corpus. These findings indicate that Korean health literacy research includes methodological development as well as psychosocial, informational, digital,

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and disease-specific applications. The results may help inform future research priorities and support the development of health literacy measurement strategies, interventions, nursing education programs, and evidence-based health communication initiatives tailored to diverse populations and health care contexts. Future studies should incorporate broader data sources and longitudinal perspectives to further advance health literacy research in Korea.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design - EP and KK; data curation and analysis - EP; interpretation of the data - EP and KK; and drafting or critical revision of the manuscript for important intellectual content - EP and KK.

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DATA AVAILABILITY STATEMENT

The bibliographic data analyzed in this study, including abstracts and author-provided keywords, were retrieved from academic databases and are available from the corresponding author upon reasonable request.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2026.0510.

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Instructions for Authors

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I. AIMS AND SCOPE

The *Korean Journal of Adult Nursing* (KJAN) is the official peer-reviewed research journal of the Korean Society of Adult Nursing (KSAN). KJAN is devoted to the dissemination of groundbreaking research on theory, practice, and education in the field of adult nursing. Research on other subject areas or issues that contribute to adult nursing is published at the discretion of the Editorial Board. The goal of KJAN is to contribute to health maintenance, health promotion, and disease prevention and management in adults by publishing research. KJAN is published four times per year at the end of February, May, August, and November.

II. RESEARCH & PUBLICATION ETHICS

1. Research Ethics

For policies on research and publication ethics that are not stated in these instructions, the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals by the International Committee of Medical Journal Editors (ICMJE) or the Committee on Publication Ethics (COPE) guidance (https://publicationethics.org/guidance) can be applied. Further, all processes of handling research and publication misconduct shall follow the applicable COPE flowchart.

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If manuscripts have been submitted or are currently under consideration for publication in KJAN, the Editorial Board will determine the nature and degree of duplicate publication or duplicate submission for the manuscript. If a manuscript has been published in KJAN, the KSAN ethics committee will determine the nature and degree of duplication.

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If a manuscript is based on a master's thesis or doctoral dissertation, the author must disclose that the manuscript is the product of his/her thesis or a dissertation for an academic degree. The first author must be the recipient of the academic degree from the work presented in the manuscript.

Any changes in authorship (addition, deletion or change in order of authorship) must be approved by the Editorial Board prior to the manuscript's acceptance for publication. To request such a change, the Editor must receive the following from the corresponding author: (a) the reason(s) for the change in the author list; and (b) written confirmation (e-mail, letter) from all authors that they agree with any addition, removal, or rearrangement.

3. Conflicts of Interest

The corresponding author will be responsible for informing the editor regarding potential conflicts of interest for all listed authors that might influence their interpretation of data. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. If there is no conflict of interest, this should also be explicitly stated as "The author(s) declared no conflict of interest."

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This journal follows the data sharing policy described in "Data Sharing Statements for Clinical Trials: A Requirement of the International Committee of Medical Journal Editors" (https://doi.org/10.3346/jkms.2017.32.7.1051). All clinical trials (as defined by the ICMJE) must be registered in a publicly accessible trial registry. For all other types of studies, including systematic reviews, prospective registration is strongly encouraged. If a study has been registered, please cite the registration number in both the abstract and body of the paper. The journal accepts registration in any of the primary registries that participate in the World Health Organization International Clinical Trials Portal (http://www.who.int/ictrp/en/), National Institutes of Health ClinicalTrials.gov (http://www.clinicaltrials.gov/), International Standard Randomized Controlled Trial Number Registry (https://www.isrctn.com/), or the Clinical Research Information Service, Korea Disease Control and Prevention Agency (KDCA) (https://cris.nih.go.kr/cris/index/index.do).

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The following are examples of data-sharing statements:

- Example 1: The data can be obtained from the corresponding authors.
- Example 2: The data can be obtained from the Supplementary Material.
- Example 3: (In the case of healthcare big data) The data can be obtained from __ (the name of the)_repository source.
- Example 4: No new data were created or analyzed during this study. Data sharing is not applicable to this article.

6. Artificial Intelligence (AI)–Assisted Technologies

At submission, authors are required to disclose whether they used AI-assisted technologies (such as Large Language Models [LLMs], chatbots, or image creators) in their work. Authors should describe how they used AI-assisted technologies in both the cover letter and the appropriate section of the manuscript. For example, if AI was used for writing assistance, this should be described in the Acknowledgments section. If AI was used for data collection, analysis, or figure generation, the authors should describe this use in the Methods section. Chatbots (such as ChatGPT) should not be listed as authors because they cannot be held responsible for the accuracy, integrity, and originality of the work, and these responsibilities are required for authorship. Therefore, authors are responsible for any submitted material that included the use of AI-assisted technologies. Authors should carefully review and edit AI-generated results because AI can generate authoritative-sounding output that can be incorrect, incomplete, or biased. Authors must ensure there is appropriate attribution of all quoted material, including full citations, and should not list AI and AI-assisted technologies as an author or co-author, nor cite AI as an author.

7. Process for Managing Publication Malpractice

If reviewers or readers suspect publication malpractice, such as fabrication, falsification, salami slicing, plagiarism, or simultaneous/ duplicate publication, inappropriate changes in authorship, an undisclosed conflict of interest, ethical problems with a submitted manuscript, a reviewer who has appropriated an author's idea or data, complaints against editors, and so on, the process of resolution will be initiated following the flowchart provided by the COPE guidance (https://publicationethics.org/guidance).

If a published manuscript is suspected of an ethics violation, the KSAN ethics committee, which includes the Editor-in-Chief of KJAN, will be convened. The procedure will be conducted in the following order: a preliminary investigation, a second investigation, and decision, in accordance with the prescribed regulations. If a published manuscript is determined to involve an ethics violation, members found to have violated this regulation and the general ethical principles of research will be subject to the following consequences, and other relevant matters shall be determined by the KSAN ethics committee.

1) The published manuscript will be retracted, and a public statement will be made regarding the reason for retraction.
2) Submission privileges to KJAN will be suspended for three years.
3) The retraction of the manuscript will be announced on KJAN's official website and in the printed journal.

III. GUIDELINES FOR MANUSCRIPT PREPARATION

1. Types of Manuscripts

KJAN publishes original articles, review articles, invited articles, and editorials.

1) *Original Articles* include full papers reporting original research. These are reports of empirical findings from high-quality basic and clinical research studies within the scope and focus of KJAN.
2) *Review Articles* include critical presentations of topics relevant to nursing theory, practice, and education regarding adult nursing. Unsolicited reviews will be considered for publication if topical, of high quality, and subject to peer review. The body of a review article should be a comprehensive, scholarly evidence-based review of the literature, accompanied by a critical analysis and reasonable conclusions.
3) *Invited Articles* provide concise reviews of a subject of importance to nursing researchers written by an invited expert in nursing science.
4) *Editorials* are commissioned by editors, and may include comments on manuscripts included, recent research trends in the field of adult nursing, and opinions on relevant topics.

2. General Guidelines

1) **Language and style:** Manuscripts should be written in English. The paper size setting should be A4, and the file should be compatible with Microsoft Word. The formatting requirements are as follows: the texts should be double-spaced and in Times New Roman 12-point font size with margins of top 30 mm, bottom 25 mm, left 25 mm, and right 25 mm. Page numbers are placed at the bottom of each page.

2) **Manuscript length:** The manuscript has different limits depending on the type of article submitted. (1) An original article should be no more than 6,000 words; (2) A review article should not exceed 8,000 words; and (3) An editorial should be no longer than 2,500 words. This word count includes only the main body of the text (i.e., not abstract, references, tables, or figures).

3) **Abbreviations:** Do not use abbreviations in the title or abstract and limit their use in the text. Expand all abbreviations at first mention in the text. Avoid using abbreviations in the article title. For standard abbreviated words and units, refer to the NLM (National Library of Medicine) Style Guide for Authors, Editors, and Publishers, 2nd Edition (2007) (http://www.nlm.nih.gov/citingmedicine).

4) **Description of participants:** Authors should ensure correct use of the terms sex (when reporting biological factors) and gender (identity, psychosocial or cultural factors), and, unless inappropriate, report the sex or gender of study participants, the sex of animals or cells, and describe the methods used to determine sex or gender. If the study was done involving an exclusive population, for example in only one sex, authors should justify why, except in obvious cases (e.g., prostate cancer). Authors should define how they determined race or ethnicity and justify their relevance.

5) **Permissions:** Authors should obtain permission from the copyright owners to use measurements or instruments for their studies. Permission to reproduce previously published material must also be obtained in writing from the copyright holder (usually the publisher) and acknowledged in the manuscript.

6) **Describing machinery or technical equipment:** Generic names should be used. When proprietary brands are used in research, include the name of the brand and the manufacturer, city (state), and nation in parentheses after the first mention of the generic name in the Methods section. Brand names are identified by symbols such as TM and ®, and should only be used when necessary.

7) **References and citation style:** References and citations follow the National Library of Medicine (NLM) Style. The submitting authors are responsible for ensuring adherence to NLM guidelines.

3. Research Reporting Guidelines

Authors are encouraged to adhere to relevant reporting guidelines when describing their study. Reporting guidelines endorsed by the journal are listed below, from the EQUATOR network (https://www.equator-network.org/).

Observational cohort, case-control, and cross-sectional studies
Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)
Meta-analysis of Observational Studies in Epidemiology (MOOSE)
Qualitative studies
Consolidated Criteria for Reporting Qualitative Research (COREQ)
Standards for Reporting Qualitative Research (SRQR)
Quasi-experimental/ non-randomized trials
Transparent Reporting of Evaluations with Non-randomized Designs (TREND)
Randomized (and quasi randomized) controlled trials
Consolidated Standards of Reporting Trials (CONSORT)
Study of Diagnostic accuracy/assessment scale
Standards for the Reporting of Diagnostic Accuracy Studies (STARD)
Systematic Review and meta-analysis
Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)
Meta-analysis of Observational Studies in Epidemiology (MOOSE)
Quality improvement studies
Standards for Quality Improvement Reporting Excellence (SQUIRE)

4. Manuscript Components

The composition of manuscripts shall be in the following order: title page, abstract and keywords, main text, references, tables and figures, and appendices. Each section begins on a new page. The main body of the manuscript (including the references, figures, tables, acknowledgements, and any funding information) should not include any identifying information, such as the authors' names or affiliations, to ensure a blind review.

1) Title page

The following should be included on the title page: (1) the title of the article; (2) the running title; (3) author information (ORCID number is required for all authors); (4) permission for measurements/instruments used in the study; (5) IRB approval institution and number; (6) disclosure; and (7) reporting guidelines checklist relevant to the research design used.

2) Abstract and Keywords

An abstract of up to 250 words for articles (including reviews) should be typed double-spaced on a separate page. It should cover the main factual points, including statements of the Purpose, Methods, Results, and Conclusion. The abstract should be accompanied by a list of three to five keywords for indexing purposes. Medical Subject Headings (MeSH) keywords (http://www.nlm.nih.gov/ mesh/meshhome.html) should be used, with careful selection of keywords that precisely reflect the focus of the study.

3) Main text

The text should be composed in the following order: Introduction, Methods, Results, Discussion, Conclusion, and References.

Introduction: Clearly state the need for this study and the main question or hypothesis of the study. Summarize the literature review or background in the area of the study.

Methods: Describe the study design, setting and samples, measurements/instruments, data collection/procedure, ethical considerations, and data analysis. If a study presents qualitative research, the instrument can be omitted. When discussing research methods, it is important to provide specific and detailed information to enable reproducibility. In the section on ethical considerations, the author should state that the study protocol was approved by the institutional review board (IRB No. ##-##-###). Please provide the initials of institutional names at the time of submission for peer review.

Results: Describe the main results in a concise paragraph. This section should be the most descriptive.

Discussion: The discussion should be based only on the reported results. It is strongly recommended that authors discuss how the study findings relate to advances in nursing practice, nursing knowledge development, and nursing implications.

Conclusion: State the conclusions and recommendations for further study. Do not summarize the study results.

4) References

In-text Citation: Citations of references in the text should follow Citing Medicine: The NLM Style Guide for Authors Editors, and Publishers 2nd edition (http://www.nlm.nih.gov/citingmedicine). References should be numbered serially in the order of appearance in the text, with numbers in brackets [ ] (e.g., social support [1], fatigue [2,3], depression [4-6]). If a reference is cited more than once, use the original reference number (e.g., social support [1,2], fatigue [2-5], depression [1,4-6]).

Reference list: References should be listed on a separate page at the end of the paper in the order of citation. The number of references should be 35 or less for an original article except for a manuscript on model construction, which is allowed to include up to 50 references. Citations of master's and doctoral dissertations should be minimized, with a maximum of three citations.

5) Tables and Figures

There should be no more than five tables and figures in total. Tables and figures should be self-contained and complement, but not duplicate, information contained in the text. Each table and figure should be placed on a separate page. All lines are to be single. Vertical lines are not acceptable. The title of a table should be placed on top. Within the title, the first letters of important words

should be capitalized (e.g., Table 1. Clinical Characteristics of the Sample). The title of the figure should be placed below the figure with the first letter capitalized (e.g., Figure 1. Path diagram of the model.). Tables and Figures should be numbered consecutively in Arabic numerals. All abbreviations used in tables should be explained in footnotes. List abbreviations in alphabetical order; do not include the word "and" before the last abbreviation (e.g., BP = blood pressure; ED = emergency department). Footnote symbols including asterisks and other symbols should be placed after abbreviations in the table. Table footnotes should be indicated with superscript symbols in sequence: †, ‡, §, ‖, ¶, #, *, ††

If the point value of a number can exceed 1, write "0" before the decimal point (e.g., t = 0.26, F = 0.98, R^2 = .61), otherwise do not write "0" before the decimal point (e.g., p < .001). The p value (as an indicator of statistical significance) should be written without a footnote and should be rounded to three decimal places (e.g., p = .003). If "p" is .000, then indicate that p is less than .001 (e.g., p < .001). Percentages (%) should be rounded off to one decimal place (e.g., 24.7%); test statistics, such as t, F, x^2, and r, should be rounded off to two decimal places (e.g., t = 0.26, F = 0.98, R^2 = .61).

6) Appendices

Authors should submit an appendix containing the final developed instrument in instrument development studies and a list of reviewed articles in a systematic review or meta-analysis.

5. Reference Format

1) Journals

(1) For six or fewer authors, list all authors:

1. Han S, Min J, Kim DK, Kong ID, Kim N. The understanding and application of telomere length as an emerging biomarker in adult nursing research: a review. Korean J Adult Nurs. 2023;35(1):1-12. https://doi.org/10.7475/kjan.2023.35.1.1

(2) For more than six authors, list the first six followed by et al.

1. Lee S, Kim MK, Hong EY, Lee JJ, Kim HJ, Kim HS, et al. Structural equation modeling on spiritual nursing care of clinical nurses based on the theory of planned behavior. Korean J Adult Nurs. 2022;34(1):27-38. https://doi.org/10.7475/kjan.2022.34.1.27

(3) Forthcoming journal articles

1. van Corven CT, Bielderman A, Wijnen M, Leontjevas R, Lucassen PL, Graff MJ, et al. Defining empowerment for older people living with dementia from multiple perspectives: a qualitative study. Int J Nurs Stud. Forthcoming 2020 Nov 10. https://doi.org/10.1016/j.ijnurstu.2020.103823

2) Periodicals or magazines

1. Rutan C. Creating healthy habits in children. Parish Nurse Newsletter. 2012 May 15:5-6.

3) Newspaper articles

1. Cho CU. Stem cell windpipe gives Korean toddler new life. The Korea Herald. 2013 May 1; Sect. 01.

4) Books

(1) Reference to an entire book

1. Hughes JH. Military veteran psychological health and social care: contemporary issues. 1st ed. London: Taylor & Francis; 2017.
2. Kim SJ. Nursing theory. Seoul: Soomoonsa; 1985.

(2) Chapter in an edited book

1. Miller CW. Applied cardiovascular physiology. In: Wingfield WE, Raffe MR, editors. The veterinary ICU book. Jackson, WY: Teton NewMedia; 2002. p. 1-14.

(3) An edited book

1. Munslow A, Rosenstone RA, editors. Experiments in rethinking history. New York, NY: Routledge; 2004.

(4) Unknown authors or editors

1. Merriam-Webster's collegiate dictionary. 10th ed. Springfield, MA: Merriam-Webster; 1995.

(5) Book with translator(s)

1. McEwen M, Wills EM. Theoretical basis for nursing. 4th ed. Koh CK, translator. Philadelphia, PA: Wolters Kluwer; 2019. p. 20-5.

(6) An encyclopedia or dictionary

1. Sadie S, editor. The New Grove dictionary of music and musicians. 6th ed. London: Macmillan; 1980.
2. Fitzpatrick JJ, Wallace M, editors. Encyclopedia of nursing research. 3rd ed. New York, NY: Springer Publishing Company; 2012.

5) Scientific and technical reports

1. Hong S, Sung M, Choi J, Kim J, Kim S. Family policies implications in the context of an increase in one-person households. Korean Women's Devel-

opment Institute Report. Seoul: Korean Women's Development Institute; 2017 July. Report No.: 1105012716.

6) Unpublished dissertations and theses: Not recommended. Maximally three dissertations and theses in total are al- lowed if necessary.
(1) Dissertations
1. Zhao JJ. Design of a 3D virtual learning environment for acquisition of cultural competence in nursing education: experience of nursing and other health care students, instructors, and instructional designers [dissertation]. Vancouver: University of British Columbia; 2019. p. 100-5.
(2) Theses
1. Huh MS. Effect of Danjeon breathing on stress urinary incontinence and quality of life in middle aged wom- en [master's thesis]. Busan: Dongeui University; 2005.

7) Conference proceedings
(1) Unpublished proceedings
1. Lankntree C, Briere J. Early data on the trauma symp- tom checklist for children (TSCC). Paper presented at: The meeting of the American Professional Society on the Abuse of Children; 1991 January 25; San Diego, CA.
(2) Posters
1. Cho YJ, Han YR. The relationship between the professional self concept, work stresses and their triage competency in emergency nurses. Poster session pre- sented at: Korean Society of Nursing Science; 2020 October 23; Seoul.

8) Web
1. Ministry of the Interior and Safety. Safety experience center [Internet]. Sejong: Ministry of the Interior and Safety; 2022 [cited 2023 January 12]. Available from: https://www.mois.go.kr/frt/sub/a06/b10/safe- tyExperience/screen.do

IV. SUBMISSION AND PEER REVIEW

1. Submission

Manuscripts should be submitted electronically via this journal's submission system (https://submit.kjan.or.kr/). The first and corresponding authors should be members of KSAN, with the exception of non-Korean authors. Under certain circumstances, non-members can submit manuscripts following approval by the Editorial Board. All correspondence, including notification of the editor's decision and requests for revisions, will be processed via this system. Authors should complete the Submission Checklist and sign the Copyright Transfer Agreement form and submit via the submission system. For any questions regarding the use of the online system, please contact the KJAN publication director via phone, fax, or e-mail.

2. Peer Review

This journal follows a double-blind peer review process. Each submission will initially be assessed by the editors to determine suitability for publication in this journal. If a submission is deemed suitable, it will typically be sent to a minimum of three reviewers for an independent expert assessment of the scientific quality. The decision as to whether an article is accepted or rejected will be taken by our editors.

1) **Preview:** The editorial committee initially assesses each submission. The primary goal is to quickly determine which papers should not be sent for peer review and which ones should. To prevent delays for authors who may wish to submit their work elsewhere, papers that do not meet basic standards or are unlikely to be published, even with a favorable peer review—such as those with insufficient novel contributions or unclear relevance to the field—may be rejected at this stage.

2) **Peer-review process:** There is a two-week peer review period, and the first decision is made after the evaluation is finished. Following the review, the Editorial Board will decide between the options: acceptable options include minor revision, major revision, or rejection. The Editorial Board may request authors to make changes to the manuscript in response to reviewers' comments. If the author deems a reviewer's opinion to be unacceptable or thinks that a reviewer has misinterpreted the data, a reasonable explanation should be provided. Authors should try their best to comply with any requests made by the reviewers to modify the manuscript.
After making changes to the manuscript, the author should upload the updated files along with a response to

each reviewer's comment. Revisions from the author must be finished within 14 days of the request. The Editorial Board will inform the author if it is not received by the deadline. The author should discuss an extension with the Editorial Board if they want to prolong the revision window past 14 days. The Editorial Board may consider further review upon the author's request. The Editorial Board will ultimately decide whether to approve the submitted manuscript for publication and may, if necessary, ask for additional alterations, edits, and deletions to the article text. Statistical editing is also done if a statistician needs to review the data professionally.
The Editor-in-Chief of KJAN will make the final decision regarding the manuscript's publication based on the reviewers' comments and the scientific merits of the manuscript. Any potential or existing conflict and issues in the manuscript must be discussed in detail with the Editorial Board.

3) **Appeals of decisions:** Any appeals against the editorial decision must be made within 2 weeks of the date of the decision letter. Authors who wish to appeal against a decision should contact the Editor-in-Chief, explaining in detail the reasons for the appeal. All appeals will be discussed with at least one other associate editor. If consensus cannot be reached thereby, an appeal will be discussed at a full editorial meeting. The process of handling complaints and appeals follows the COPE guidance (https://publicationethics.org/guidance). KJAN does not consider second appeals.

V. FINAL PREPARATION FOR PUBLICATION

1. Final Version

After the paper has been accepted for publication, the author(s) should submit the final version of the manuscript. The names and affiliations of the authors should be double-checked, and if the originally submitted image files were of poor resolution, higher-resolution image files should be submitted at this time. Symbols (e.g., circles, triangles, squares), letters (e.g., words, abbreviations), and numbers should be large enough to be legible on reduction to the journal's column widths. All symbols must be defined in the figure caption. If references, tables, or figures are moved, added, or deleted during the revision process, renumber them to reflect such changes so that all tables, references, and figures are cited in numeric order.

2. Manuscript Corrections

Before publication, the manuscript editor will correct the manuscript so that it meets the standard publication format. The author(s) must respond within 48 hours when the manuscript editor contacts the corresponding author for revisions. If the response is delayed, the manuscript's publication may be postponed to the next issue.

3. Proofs and Reprints

The author(s) will receive the final version of the manuscript as a PDF file. Upon receipt, the author(s) must notify the editorial office of any errors found in the file within 48 hours. Any errors found after this time are the responsibility of the author(s) and will have to be corrected as an erratum.

4. Correction

To correct errors in published articles, the corresponding author should contact the journal's editorial office with a detailed description of the proposed correction. Corrections that seriously affect the interpretation or conclusions of the article will be reviewed by the editors. Corrections will be published as an author correction or a publisher correction in a later issue of the journal.

Minor errors will be corrected directly in the online version of the article. An indication of the correction, along with the date it was made, will be added to the article information in both the HTML and PDF versions. A separate correction note will not be published.

VI. ARTICLE PROCESSING CHARGE

When a manuscript is accepted for publication, an article processing charge (APC) of 600 USD (KRW 600,000) per article is charged to the corresponding author.

VII. COPYRIGHT, OPEN ACCESS POLICY

1. Copyright

All manuscripts published in KJAN are protected by copyright. The copyright and transfer rights of the digital content of the published paper and journal are owned by the

KSAN. Copyright Transfer Agreement form should be submitted online at submission. All authors should print their names and sign the copyright transfer agreement.

2. Open Access Policy

History:

Enacted Jun, 1994
Revised Dec, 1999
Revised Dec, 2002
Revised Dec, 2003
Revised Dec, 2006
Revised Dec, 2007
Revised Jun, 2008
Revised Dec, 2008
Revised Feb, 2009
Revised Jun, 2009
Revised Apr, 2010
Revised Aug, 2010
Revised Jun, 2012
Revised Jul, 2014
Revised Aug, 2016
Revised Feb, 2018
Revised Aug, 2018
Revised Dec, 2018
Revised Jun, 2020
Revised Mar, 2023
Revised Aug, 2023
Revised May, 2025

VIII. OTHER EDITORIAL POLICY

1. Archiving Policy

All manuscripts published in KJAN are freely available through open access to read and download from any electronic link, including those found on the KJAN website (http://www.kjan.or.kr/) immediately and permanently after publication.

Submission Checklist

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Before submitting the manuscript, please review the following items and mark the applicable content with a "✓" (check-mark).

1. General Considerations

☐ The manuscript should be written according to the research and publication ethics of KJAN.
☐ The first and corresponding authors should be members of the KSAN (*Foreign researchers may submit to KJAN, even though they are not KSAN members).
☐ Copyright transfer agreement signed by all authors and relevant EQUATOR reporting guidelines checklist should be submitted by submission system.
☐ Institutional review board (IRB) approval institution and number:

2. Title page

☐ Please follow the title page template available online.

3. Manuscript preparation

3.1. General guidelines

☐ A4 paper size, 12-point font Times New Roman in MS Word file.
☐ Line space: double spacing / Margins of 30 mm on the top and 25 mm on the bottom, left, and right.
☐ Page numbers at the bottom of each page.
☐ Subheadings of abstract, text, references, and tables and figures.
☐ Original article should be no more than 6,000 words; a review article should not exceed 8,000 words; and an editorial should be no longer than 2,500 words.

3.2. Abstract and Keywords

☐ 250 words or fewer in the abstract.
☐ Subheadings of Purpose, Methods, Results, and Conclusion.
☐ Three to five keywords from MeSH terms.

3.3. Main Text

☐ The main text consists of introduction, methods, results, discussion, conclusion, and references.

3.4. References

☐ The number of references should be 35 or fewer (50 or fewer for model construction).
☐ References follow NLM style.
☐ All references are written with DOIs.
☐ All citations in the paper should have a complete and accurate corresponding reference in the reference list.
☐ Present recent (within 5 years) articles to the extent possible.

3.5. Tables and Figures

☐ The total number of tables and figures should be 5 or fewer.
☐ All abbreviations should be described below the tables or figures.
☐ When numbers are used, the units of the numbers should also be given.
☐ All table and figure numbers should be mentioned in the text.
☐ Tables and figures are presented on separate pages after the references, with one table and figure per page.

Manuscripts submitted to KJAN will be returned if they do not conform to the submission guidelines of KJAN. The authors of this article understand and confirm the above instructions.

Name of corresponding author: _____ Date: _____/_____/_____ (Signature)

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1. Transfer of Copyright

Copyright of this manuscript shall be transferred to the Korean Society of Adult Nursing [KSAN] if it is published in the Korean Journal of Adult Nursing [KJAN]. The author possesses all the rights except for the copyright, including the right to use all or a part of this manuscript for applying for patent or writing a future thesis. The author may use the material of this manuscript in another manuscript after obtaining a written approval. All the authors of this manuscript have made practical and intelligent contributions to this manuscript, and share public responsibility for the contents of this manuscript. In addition, this manuscript has not been published by or submitted to another academic journal so far, and is not planned to be contributed to any other academic journal as of now.

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The author(s) of this manuscript clearly state all the interests related to this manuscript including financial interests (benefit of research fund, employment, possession of stocks, lecturer's fees or consultancy fees, material support, etc.) and personal interests (concurrent position, conflict of interest, conflict in intellectual property rights, etc.).

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