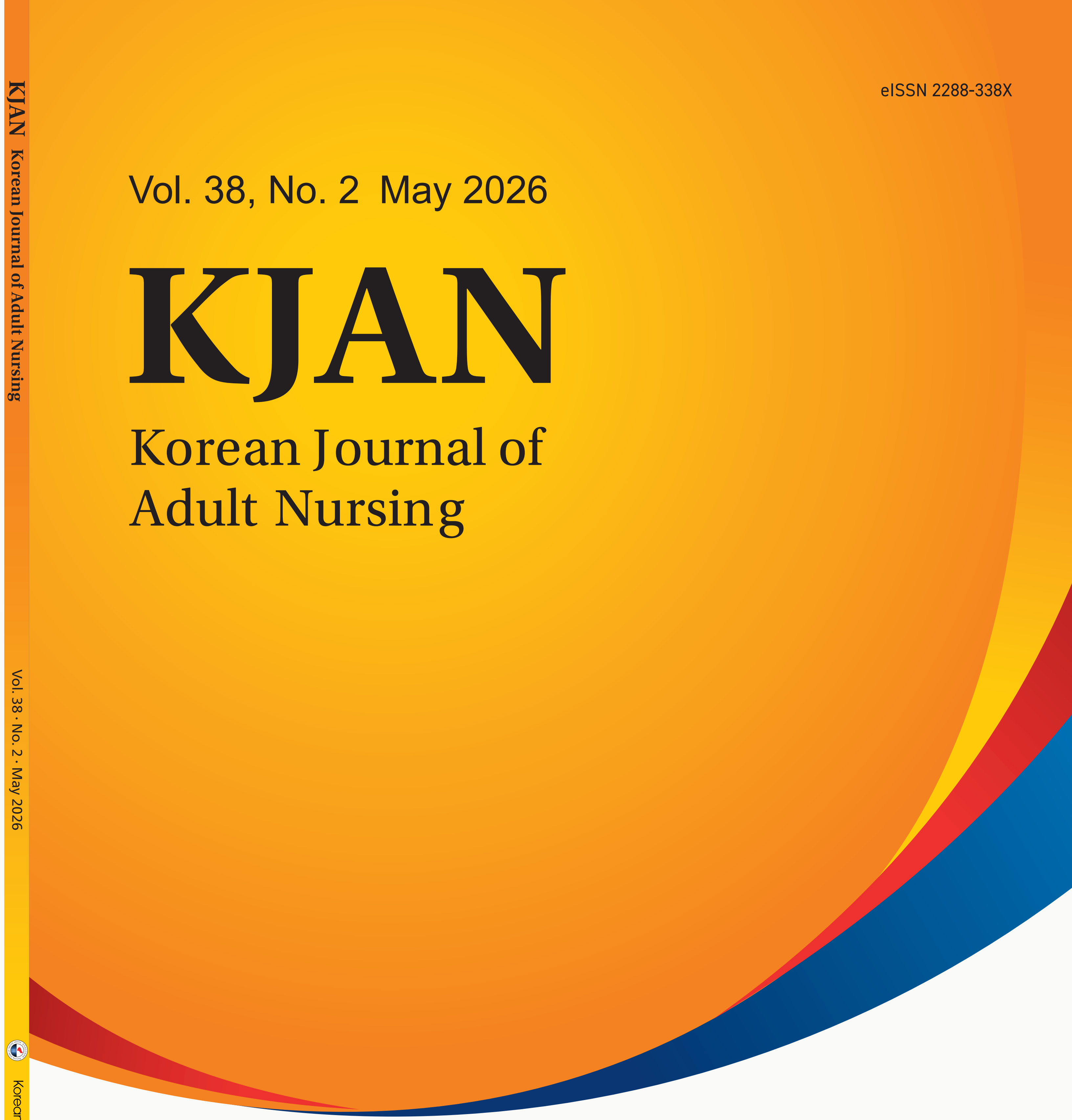
Korean Society of
Adult Nursing

KJAN Korean Journal of Adult Nursing

Vol. 38 · No. 2 · May 2026

Korean Society of Adult Nursing



eISSN 2288-338X

Vol. 38, No. 2 May 2026

KJAN

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The Korean Journal of Adult Nursing (KJAN) is the official peer-reviewed research journal of the Korean Society of Adult Nursing. KJAN is devoted to the dissemination of groundbreaking research on the theories, practices, and education of adult nursing. Research on other subject areas or issues that contribute to adult nursing are published at the discretion of the Editorial Board. The goal of KJAN is to contribute health maintenance, health promotion, disease prevention, and recovery from diseases in adults by publishing research. KJAN is published four times per year at the end of February, May, August, and November. It was launched in 1989. The official title of the Journal is Korean Journal of Adult Nursing and the abbreviated title is Korean J Adult Nurs. This Journal is indexed in SCOPUS, CINAHL, KoreaMed, Google Scholar, and KCI.

Enacted in March 1989
Publishing 31 May, 2026

- **Publisher** Korean Society of Adult Nursing

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Full text is freely available URL: https://kjan.or.kr

* The articles in this journal are indexed/tracked/covered by SCOPUS, CINAHL, KoreaMed, KCI, Google scholar.

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Contents

KJAN
Korean Journal of
Adult Nursing

Vol. 38, No. 2 May 2026

Review Articles

Original Articles

REVIEW ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 125-138, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2025.1118

KJAN
Korean Journal of
Adult Nursing

Effects of Self-Management Interventions Based on Shared Decision-Making in Patients with Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis

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Received: November 18, 2025
Revised: May 14, 2026
Accepted: May 17, 2026

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Purpose: This systematic review and meta-analysis examined the effects of shared decision-making (SDM)-based self-management interventions on health outcomes in patients with chronic obstructive pulmonary disease (COPD). **Methods:** Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, three databases were searched in July 2022, supplemented by gray literature and citation searching. Randomized controlled trials that integrated SDM components into COPD self-management programs were included. Two reviewers independently performed study selection, data extraction, and risk-of-bias assessment. Random-effects models were used to pool odds ratios (ORs) for dichotomous outcomes and standardized mean differences (SMDs) for continuous outcomes, with 95% confidence intervals (CIs). Outcomes included hospital readmission, health-related quality of life (HRQoL), functionality, physical symptoms, psychological symptoms (depression and anxiety), and self-efficacy. **Results:** Seven studies ($n = 1,028$) met the inclusion criteria. SDM-based interventions showed no statistically significant difference in hospital readmission ($OR = 1.59$, 95% CI, 0.79 to 3.19; $I^2 = 49.1\%$) and no significant improvement in HRQoL ($SMD = 0.19$, 95% CI, −0.14 to 0.51; $I^2 = 98.3\%$). Depression showed no significant effect ($SMD = -0.01$, 95% CI, −0.39 to 0.38; $I^2 = 98.1\%$). Self-efficacy improved slightly ($SMD = 0.12$, 95% CI, 0.01 to 0.23; $I^2 = 89.4\%$), with substantial heterogeneity. Evidence for other secondary outcomes was inconsistent. **Conclusion:** SDM-based self-management interventions did not demonstrate clear benefits for hospital readmission or HRQoL in patients with COPD. Given the heterogeneity across studies, these findings should be interpreted cautiously. Future trials should use standardized SDM frameworks, assess implementation fidelity, and apply consistent outcome measures to clarify the role of SDM in COPD management.

Key Words: Chronic obstructive pulmonary disease; Self-management; Decision making, shared; Systematic review; Meta-analysis

INTRODUCTION

Overall disease burden is commonly measured using disability-adjusted life years (DALYs) [1]. The Global Burden of Disease Study reported 212.3 million cases of chronic obstructive pulmonary disease (COPD) worldwide in 2019, resulting in 3.3 million deaths and 74.4 million DALYs. This burden is expected to increase because of population aging, smoking, air pollution, and occupational exposure [2]. Self-management strategies are essential for reducing the disease burden because they improve symptom control and health-related quality of life (HRQoL) while reducing healthcare utilization and associated costs [3]. According to the Global Initiative for Chronic Obstructive Lung Disease 2024 report [4], COPD self-management includes patient education, individualized action plans, and consistent communication with healthcare professionals to enhance patients' motivation, confidence, and competence in managing their condition. These interventions have been shown to improve HRQoL and reduce respiratory disease-related hospital admissions [5,6], ultimately promoting better long-term outcomes [7].

Shared decision-making (SDM) is defined as a collaborative process in which clinicians and patients share the best available evidence, explore treatment or management options, and select strategies that reflect the patient's values and preferences [8]. When applied to chronic disease management, SDM promotes patient engagement, supports problem-solving skills, and facilitates the establishment of realistic self-management goals [9,10]. SDM-based self-management emphasizes the joint development of action plans, progress review, and goal adjustment throughout the self-management period [11]. In COPD, SDM-based self-management interventions may be incorporated into the development and revision of individualized self-management plans through collaboration between patients and healthcare professionals [11].

Several frameworks have described the essential components of SDM. For example, the Agency for Healthcare Research and Quality (AHRQ) proposed the SHARE (seek your patient's participation [S], help your patient explore and compare treatment options [H], assess your patient's values and preferences [A], reach a decision with the patient [R], and evaluate the patient's decision [E]) approach, described later, as a structured process for implementing SDM [12]. Legare and Witteman [13] similarly emphasized three core elements: patient-provider involvement, bidirectional information exchange, and deliberation regarding treatment preferences. However, SDM-based self-management interventions in previous studies have varied considerably in the extent to which these components were applied. Many interventions incorporated only selected SDM steps, and outcomes were often measured indirectly through satisfaction, preferences, or self-efficacy rather than clinical indicators [14]. Previous COPD self-management studies have primarily focused on hospital readmission and HRQoL as major health outcomes [15], whereas secondary outcomes have included functionality, physical and psychological symptoms, and self-efficacy, which may mediate improvements in HRQoL and reductions in readmission [16,17]. With increasing attention to SDM in healthcare research, its direct impact on COPD outcomes requires further clarification.

Although SDM has been associated with beneficial effects in chronic disease management [18,19], evidence regarding its specific influence in patients with COPD remains limited and inconsistent. In the broader SDM literature, beneficial effects have been reported more consistently for affective-cognitive outcomes, whereas effects on behavioral and health outcomes are more variable and may depend on how SDM is measured [19]. Consistent with this pattern, a systematic review of SDM interventions for chronic respiratory diseases reported substantial heterogeneity in the included studies and outcome measures, which precluded meta-analysis and limited the generalizability of the findings to COPD-specific contexts [9]. Existing systematic reviews of COPD self-management have primarily synthesized multicomponent self-management programs, making it difficult to isolate SDM as a core mechanism [6]. Given the variation in SDM applications, uncertainty regarding its effectiveness, and growing emphasis on patient-centered care, synthesis of the existing evidence is needed to determine the role and potential benefits of SDM in COPD self-management.

Therefore, this study conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to evaluate the effects of SDM-based self-management interventions on hospital readmission and HRQoL and to examine secondary outcomes, including functionality, physical and psychological symptoms, and self-efficacy, in patients with COPD.

METHODS

1. Study Design

This study was a systematic review and meta-analysis of RCTs. The protocol was registered in the Prospective Register of Systematic Reviews (PROSPERO; CRD42022366542). This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [20].

2. Search Strategy

A systematic search was conducted in July 2022 using three core databases—MEDLINE, Ovid-EMBASE, and the Cochrane Central Register of Controlled Trials (CENTRAL)—to identify studies available through July 2022. An additional search for unpublished studies, including gray literature such as dissertations, was conducted using ProQuest Dissertations & Theses Global and Google Scholar. Citation searching was also performed. The core terms COPD, self-management, and SDM were selected based on the review question. Medical Subject Headings (MeSH) and free-text terms were identified and tested in MEDLINE and CENTRAL during preliminary scoping to refine each core concept. A search strategy was then developed for each core concept. The strategy was tailored to each database, and terms were combined using Boolean operators and database-specific syntax, including selected truncation and wildcard terms. No restrictions were placed on publication period or language. All identified records were published in English; therefore, no studies were excluded on the basis of language. The full search strategy for each database is presented in Supplementary Data 1. To contextualize the findings, guidelines and narrative reviews published after the final search date were cited for background only and were not used for study identification, eligibility assessment, or quantitative synthesis.

3. Eligibility Criteria

The review included studies of adults aged ≥40 years who had been diagnosed with COPD according to diagnostic criteria, as well as studies that included patients with COPD in the total cohort (population). The age threshold of 40 years was applied because COPD is most commonly diagnosed in middle-aged and older adults, and this cutoff is widely used in COPD case-finding and epidemiological research [2,4].

The intervention was defined as an SDM-based self-management program that included at least two elements of the SHARE model proposed by AHRQ [12]. The SHARE steps include seeking the patient's participation, helping the patient explore and compare management options, assessing the patient's values and preferences, reaching a shared decision, and evaluating and revising the decision as needed. Interventions that applied two or more of these steps before or during development of the self-management plan were classified as SDM-based self-management interventions. The self-management intervention was required to include at least two self-management components, such as education, exercise, medication management, physical activity, or lifestyle modification. The control group was required to receive either usual care or self-management interventions without SDM.

The primary outcomes were HRQoL and hospital readmission rates. Secondary outcomes included general functionality, physical and psychological symptoms, and self-efficacy. Outcome selection was informed by the SDM consequences framework proposed by Elwyn et al. [21], which distinguishes between proximal, distal, and distant consequences of collaborative deliberation. Accordingly, self-efficacy was prespecified as an SDM-relevant determinant aligned with distal consequences, and hospital readmission was designated as a downstream healthcare utilization endpoint aligned with distant consequences. HRQoL was included as a patient-centered health outcome that may change through sustained implementation of the individualized self-management plan developed through SDM [3,6,7,15-17]. General functionality and physical and psychological symptoms were also included as patient-centered outcomes commonly assessed in COPD self-management and SDM-related respiratory interventions [6,7,9,17].

Only RCTs were included in the analysis. Studies using secondary or tertiary data, abstracts or protocol-only articles, and studies conducted primarily in palliative or end-of-life care settings were excluded. Palliative care-based interventions were excluded because their primary aims and core components, such as symptom palliation and advance care planning, differ from those of SDM-based self-management interventions; including them could have introduced substantial clinical heterogeneity in intervention intent and expected outcomes [22].

However, one study involving patients with both COPD and congestive heart failure was not excluded because its results were partially obtained from patients with COPD. Furthermore, both diseases share common symptoms, such as shortness of breath and wheezing, which can result in reduced physical activity despite having different causes [23].

4. Study Selection and Data Extraction

After the search, all identified studies were uploaded to

EndNote X8 8.2 (Clarivate Analytics, Philadelphia, PA, USA), and duplicates were removed. Two trained reviewers (SYY and SYL) independently screened titles and abstracts to identify potentially eligible studies. The full texts of potentially eligible articles were then assessed independently by the same reviewers. Disagreements were resolved through discussion and consultation with a third reviewer (JYC) when necessary; however, no disagreements required third-party adjudication.

Data were extracted using a structured, predesigned Excel form. Extracted data included general study characteristics, participant characteristics, intervention characteristics, self-management contents, SDM processes, and outcomes. The SDM process was analyzed using the SHARE approach developed by AHRQ [12]. The SDM components implemented in each study were coded according to the five AHRQ SHARE steps based on the AHRQ factsheet [12]. Two trained reviewers (SYY and SYL) independently coded the presence of each SHARE step for each included study based on intervention descriptions and supplementary materials, when available. Discrepancies in SHARE-step coding were resolved through discussion, and if consensus could not be reached, a third reviewer (JYC) was consulted; however, no unresolved discrepancies occurred.

When data were missing, the corresponding authors were contacted by e-mail to request relevant unpublished information. Because one study did not report the standard deviation for HRQoL, an e-mail was sent to the author to request statistical values; however, the data could not be obtained. Two trained reviewers (SYY and SYL) randomly selected two studies and conducted a pilot extraction test. Subsequently, one reviewer extracted general study data, and two reviewers independently coded the SHARE steps and reached agreement.

5. Quality Assessment

Literature quality was assessed using the Risk of Bias 2 tool (RoB 2) [24]. The tool comprises five domains: bias arising from the randomization process, bias due to deviations from the intended interventions, bias due to missing outcome data, bias in outcome measurement, and bias in selection of the reported result. Two reviewers (SYY and SYL) independently assessed the RoB for each study. Consensus between the two reviewers was reached through discussion. A third reviewer (JYC) was consulted if consensus could not be achieved.

6. Data Synthesis and Analysis

Effect size and heterogeneity analyses for hospital readmission, HRQoL, general functioning, physical symptoms, psychological symptoms, and self-efficacy were performed using Morris's procedure [25] for pretest-posttest control group designs, implemented in R with the "metafor" package [26]. Meta-analysis was performed only when three or more studies were available for an outcome [27]. When fewer than three studies were available, quantitative pooling was not conducted, and findings were summarized narratively; accordingly, general functioning, dyspnea, fatigue, and anxiety were not eligible for meta-analysis. A random-effects model was chosen to account for the inherent diversity of the studies because treatment effects were expected to differ across the selected studies beyond random sampling error.

Pooled effects are expressed as odds ratios (ORs) with 95% confidence intervals (CIs) for dichotomous outcomes. For continuous outcomes, standardized mean differences (SMDs) with 95% CIs were used when different instruments were applied [27]. To align scale directions before computing SMDs, all continuous outcomes were oriented so that higher values consistently indicated improvement. For instruments in which higher scores reflected worse health status or symptoms, the sign of the effect estimate was reversed before standardization; standard deviations were not modified. When the posttest standard deviation was unavailable, it was replaced with the pretest standard deviation, and vice versa [27]. When outcomes were reported at multiple follow-up time points within a study, data from the longest follow-up time point were extracted for meta-analysis. When a study included multiple outcomes for the same construct measured using different scales, a single weighted mean effect size was calculated for that study.

Heterogeneity among studies was assessed using forest plots, which allowed examination of overlap in CIs and variation in effect estimates. Heterogeneity among individual effect sizes was also assessed using Higgins' I^2 [28]. In this context, I^2 values of 25%, 50%, and ≥75% indicated low, moderate, and high heterogeneity, respectively. Given the small number of studies, the Hartung-Knapp adjustment with t-based inference was applied [29]. No additional analyses, such as subgroup analyses, meta-regression, or sensitivity analyses, were conducted because the number of studies per outcome was insufficient. Given the small number of studies per outcome, a full GRADE (Grading of Recommendations Assessment, Development and Evaluation) Summary of Findings table was not produced; however, a brief outcome-level narrative assessment of certainty of evidence was conducted according to the GRADE domains [27].

RESULTS

1. Study Identification and Selection

A total of 874 studies were identified through searches of the three databases, gray literature, and citation searching. After duplicates were removed and the titles and abstracts of 710 studies were reviewed, 695 studies were excluded based on the inclusion and exclusion criteria, leaving 15 studies for full-text review. After the full texts were reviewed, four studies were excluded because they did not apply SDM, two because they did not evaluate primary or secondary outcome variables, two because they focused on methodological feasibility, and one because it was conducted in a palliative care setting. Citation searching identified one additional study. Thus, seven studies were included in this systematic review and meta-analysis; the list is provided in Supplementary Data 2. Figure 1 shows the full study selection process using a PRISMA flow diagram.

2. Characteristics of the Literature

Table 1 shows the characteristics of the selected studies [A1-7]. Regarding year of publication, four studies (57.1%) [A1-3,A7] were published between 2018 and 2022, two studies (28.6%) [A4,A6] were published between 2015 and 2013, respectively, and one study (14.3%) [A5] was published before 2013. The selected studies were conducted in Australia, New Zealand, South Korea, Spain, Sweden, Taiwan, and the United States.

The study settings were primary care institutions in three studies (42.8%) [A5-7], inpatient hospital settings in two studies (28.6%) [A2,A3], and outpatient hospital settings in two studies (28.6%) [A1,A4]. Six studies (85.7%) included

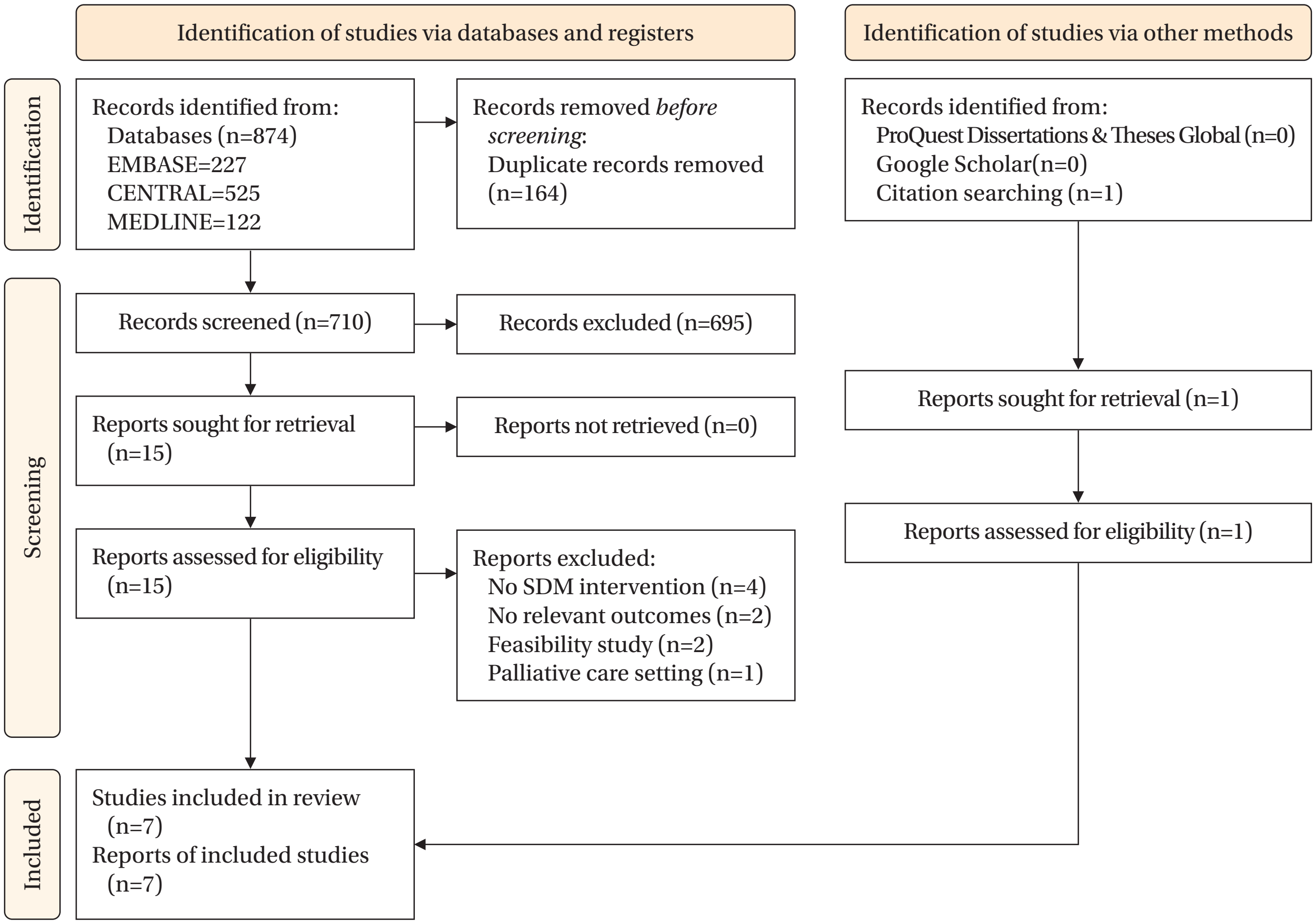


Figure 1. Flow diagram of the study selection process. SDM = shared decision-making.

Table 1. Characteristics of the Included Studies (N=7)

No.	Author (year)	Country	Setting	Provider	Participants	Intervention	Intervention period	Control	Self-management contents	SDM process (SHARE)	Outcomes (tools)
A1	Chang and Dai (2019)	Taiwan	A medical center	A nurse manager	Patients with clinical COPD diagnosis established using the pulmonary function test (FEV1/FVC <0.7), aged >20 years (60, I=30 vs. C=30)	Motivating, self-learning, reflecting, action-plan verbalizing, and action-taking (MSRAA) flipped self-management education program	3 Months	Conventional patient education	- Pursed-lip breathing - Smoking cessation - Adopting environmental control measures - Preventing respiratory tract infections - Taking medications regularly - Exercising regularly	H R E	- HRQoL (CAT) - Self-efficacy (PRAISE)
A2	Collinsworth et al. (2018)	USA	A community hospital	Registered respiratory therapists	COPD patients at least 24 hours after admission (308, I=141 vs. C=167)	COPD education, SDM-based self-management planning, and follow-up telephone calls	6 Months	COPD education	- Symptom management - Medication management - Diet and nutrition - Stress and coping - Smoking cessation - Physical activity	H R E	- Hospital readmissions - HRQoL (CAT)
A3	Granados-Santiago et al. (2020)	Spain	2 Hospitals	NA	Patients hospitalized due to AECOPD (42, I=21 vs. C=21)	Individualized SDM and patient engagement programs added to standard treatment	Hospitalization days	Standard treatment	-Pharmacological management - Symptom control - Healthy lifestyle promotion	S H A R	- HRQoL (EQ-5D) - General functionality (FIM) - Physical symptoms (Borg scale)
A4	Lee et al. (2015)	South Korea	3 Outpatient clinics at 1 university hospital	A registered nurse	COPD patients aged 40–80 years in stable condition and expected to live ≥6 months (151, I=78 vs. C=73)	Problem-solving counseling	6 Months	Usual care	- Assessment of severity and managing exacerbation - Medication - Managing respiratory symptoms - Oxygen therapy - Exercise - Nutrition - Stress management - Smoking cessation - Sleep - Infection - Immunization	H R E	- Psychological symptoms (CES-D) - Self-efficacy (CSES)

(Continued on the next page)

Table 1. Continued

No.	Author (year)	Country	Setting	Provider	Participants	Intervention	Intervention period	Control	Self-management contents	SDM process (SHARE)	Outcomes (tools)
A5	Rea et al. (2004)	New Zealand	66 GP practices	Participant's GP and practice nurse	Patients with moderate to severe COPD (135, I = 83 vs. C = 52)	Care plans with predetermined goals, action plans, and education on COPD management	12 Months	Conventional care	- Action plan - Smoking cessation - Medication and use of inhalers - Influenza vaccination - Participation in pulmonary rehabilitation	R E	- Hospital admissions - HRQoL (SF-36 and CRQ)
A6	Walters et al. (2013)	Australia	31 General practices	Community health nurses	Patients aged > 45 years with COPD, smoking history > 10 pack-years, FEV1/FVC < 0.7, and predicted FEV1 of 30%–80% after bronchodilatation (182, I = 90 vs. C = 92)	Psychoeducation, self-management skills training, cognitive coping-skills training, communication-skills training, and promotion of self-efficacy	12 Months	Usual care plus monthly phone calls	- Smoking cessation - Nutrition and alcohol - Physical activity - Psychosocial well-being - Symptom management	R E	- Hospital admission - HRQoL (SF-36, SGRQ, and SWLS) - Psychological symptoms (CES-D and HAD) - Self-efficacy (SEMCD)
A7	Zakrisson et al. (2019)	Sweden	9 PHC centers	A physiotherapist and a nurse	Physician-diagnosed congestive heart failure or spirometry-verified diagnosis of COPD (FEV1/FVC < 0.70 and predicted FEV1 < 80% after bronchodilatation) as well as any symptoms (150, I = 73 vs. C = 77)	Individualized action plans, goal-setting discussions, and support for patients to develop self-management skills and disease-related knowledge	3 Months	Usual care	- Individualized action plans - Supporting the patients to practice skills and gain knowledge	S R E	- HRQoL (SF-36) - General functionality (COPM) - Physical symptoms (FIS-physical) - Psychological symptoms (HADS) - Self-efficacy (ESES)

AECOPD = acute exacerbations of chronic obstructive pulmonary disease; C = control group; CAT = COPD Assessment Test; CES-D = Center for Epidemiologic Studies Depression Scale; COPD = chronic obstructive pulmonary disease; COPM = Canadian Occupational Performance Measure; CRQ = chronic respiratory disease questionnaire; CSES = Coping Self-Efficacy Scale; EQ-5D = EuroQol 5-Dimension; ESES = Exercise Self-Efficacy Scale; FEV1 = Forced Expiratory Volume in 1 second; FIM = functional independence measure; FVC = forced vital capacity; GP = general practitioner; HADS = Hospital Anxiety and Depression Scale; I = intervention group; NA = not applicable; PHC = primary healthcare; PRAISE = Pulmonary Rehabilitation Adapted Index of Self-Efficacy; SDM = shared decision-making; SEMCD = Self-Efficacy to Manage Chronic Disease; SF-36 = 36-Item Short Form Survey; SGRQ = St. George's Respiratory Questionnaire; SHARE = seek your patient's participation (S), help your patient explore and compare treatment options (H), assess your patient's values and preferences (A), reach a decision with the patient (R), and evaluate the patient's decision (E); SWLS = Satisfaction with Life Scale.

only patients with COPD, and one study (14.3%) [A7] included patients with both COPD and congestive heart failure. The number of participants ranged from 42 to 308. The interventions included general COPD education and SDM support, as well as a flipped education program [A1], problem-solving counseling [A4], and health mentoring [A6]. The intervention period ranged from during hospitalization to 12 months. The self-management interventions included symptom management, medication adherence, diet, stress management, smoking cessation, lifestyle modification, exercise, and infection control.

3. Shared Decision-Making

Table 1 shows that none of the studies implemented all five SDM steps. Based on the SHARE approach, one study (14.3%) performed four steps [A3], and four studies (57.1%) performed three steps [A1,A2,A4,A7]. Step 1 involves encouraging patients to take an active role in decision-making, as implemented by Granados-Santiago et al. [A3], and creating a positive and supportive atmosphere to engage patients and their families in decision-making alongside the healthcare team, as demonstrated by Lee et al. [A4]. Step 2 focuses on presenting and explaining the options necessary for self-management strategies. Collinsworth et al. [A2] and Granados-Santiago et al. [A3] used these methods to support self-management strategies, whereas Chang and Dai [A1] and Rea et al. [A5] provided guidance and materials through booklets. Step 3 reflects patients' preferences, interests, and priorities when determining self-management strategies, as implemented by Granados-Santiago et al. [A3]. Step 4 involved collaboratively setting COPD self-management action plans or goals and was applied in all studies [A1-7]. Finally, step 5 includes methods for checking patients' self-management progress and, when necessary, revising self-management goals. This step was applied in six studies [A1,A2,A4-7].

4. Quality Assessment of the Selected Studies

Assessment using the Cochrane RoB 2 tool showed that four articles [A2,A3,A6,A7] had a low RoB. Two articles [A4,A5] had some concerns because of insufficient information on randomization and data collection or the absence of a prespecified analysis plan. One article [A1] had a high RoB because of lack of blinding and the potential for response bias from self-reported surveys (Figure 2).

5. Effects of Shared Decision-Making Interventions

1) Primary outcomes

Three studies reported hospital readmissions (Figure 3A). The pooled results (n = 625) showed no statistically significant difference in hospital readmission between SDM-based interventions and controls (OR = 1.59, 95% CI, 0.79 to 3.19; $p = .318$), with moderate heterogeneity ($I^2 = 49.1\%$, $p = .140$). Five studies (n = 487) examined the effect of SDM on HRQoL using the COPD Assessment Test, EuroQol 5-Dimension, 36-Item Short Form Survey, and St. George's Respiratory Questionnaire (Figure 3B). The pooled results indicated no significant improvement in HRQoL (SMD = 0.19, 95% CI, –0.14 to 0.51; $p = .184$), with very high heterogeneity ($I^2 = 98.3\%$, Q = 242.20, degrees of freedom [df] = 4; $p < .001$) (Table 2).

2) Secondary outcomes

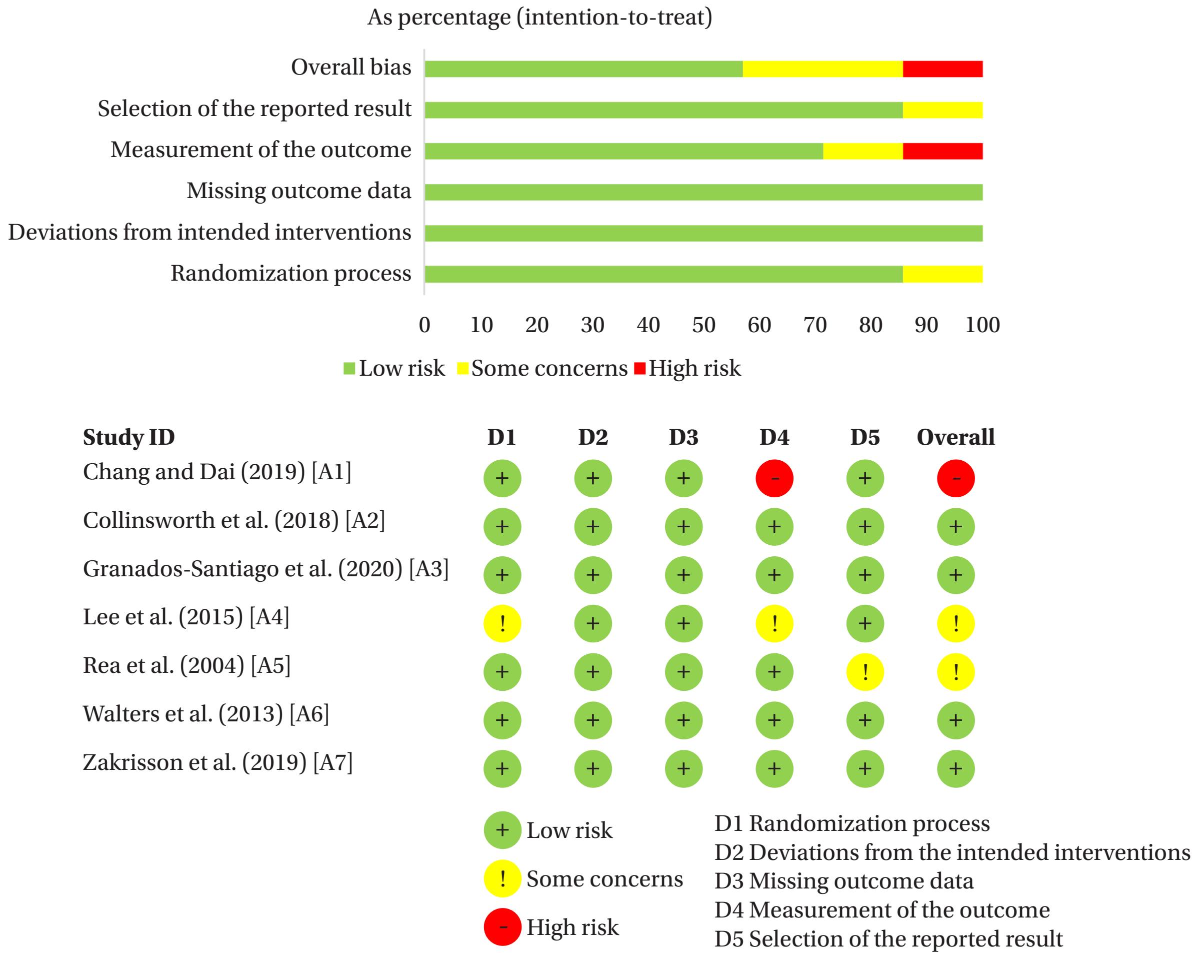
Depression was assessed in three studies using the Center for Epidemiologic Studies Depression Scale and Hospital Anxiety and Depression Scale (Figure 3C). The pooled estimate showed no significant effect on depression (SMD = –0.01, 95% CI, –0.39 to 0.38; $p = .962$), with considerable heterogeneity ($I^2 = 98.1\%$, Q = 105.15, df = 2; $p < .001$) (Table 2).

Self-efficacy was measured using the Coping Self-Efficacy Scale, Exercise Self-Efficacy Scale, Pulmonary Rehabilitation Adapted Index of Self-Efficacy, and Self-Efficacy to Manage Chronic Diseases. The pooled estimate showed a small but statistically significant positive effect of SDM-based interventions on self-efficacy (SMD = 0.12, 95% CI, 0.01 to 0.23; $p = .043$), with high heterogeneity ($I^2 = 89.4\%$, Q = 28.31, df = 3; $p < .001$) (Table 2, Figure 3D).

General functioning showed mixed findings in two studies [A3,A7]. Regarding physical symptoms, dyspnea improved in one study [A3], whereas fatigue showed no significant between-group difference in another study [A7]. Anxiety outcomes were also inconsistent across the two studies that reported this outcome [A6,A7].

6. Certainty of Evidence (GRADE-Informed Narrative Assessment)

A GRADE-informed narrative assessment of certainty was conducted for each outcome. Because the number of included trials per outcome was small and reporting was limited, a formal Summary of Findings table was not pro-



Study ID	D1	D2	D3	D4	D5	Overall
Chang and Dai (2019) [A1]	+	+	+	-	+	-
Collinsworth et al. (2018) [A2]	+	+	+	+	+	+
Granados-Santiago et al. (2020) [A3]	+	+	+	+	+	+
Lee et al. (2015) [A4]	!	+	+	!	+	!
Rea et al. (2004) [A5]	+	+	+	+	!	!
Walters et al. (2013) [A6]	+	+	+	+	+	+
Zakrisson et al. (2019) [A7]	+	+	+	+	+	+

+ Low risk
! Some concerns
- High risk

D1 Randomization process
D2 Deviations from the intended interventions
D3 Missing outcome data
D4 Measurement of the outcome
D5 Selection of the reported result

Figure 2. Assessment of the risk of bias in the included studies.

duced; instead, certainty was rated narratively across key GRADE domains, including RoB, inconsistency, indirectness, and imprecision [27], where assessment was feasible. Overall certainty ranged from moderate to very low.

For hospital readmission (3 studies; OR = 1.59, 95% CI, 0.79 to 3.19; $I^2 = 49.1\%$), certainty was rated as moderate and was downgraded by one level for imprecision because of wide CIs spanning potential benefit and harm. For HRQoL (5 studies; SMD = 0.19, 95% CI, –0.14 to 0.51; $I^2 = 98.3\%$), certainty was rated as very low and was downgraded for very serious inconsistency and imprecision. For depression (3 studies; SMD = –0.01, 95% CI, –0.39 to 0.38; $I^2 = 98.1\%$), certainty was rated as very low and was downgraded for very serious inconsistency and imprecision. For self-efficacy (4 studies; SMD = 0.12, 95% CI, 0.01 to 0.23; $I^2 = 89.4\%$), certainty was rated as low and was downgraded for serious inconsistency and imprecision because of substantial heterogeneity and variability in effect estimates across trials.

DISCUSSION

This systematic review and meta-analysis evaluated the effects of SDM-based self-management programs on hospital readmission and HRQoL in patients with COPD. Seven studies with a combined sample size of 1,028 participants were included. The pooled estimates did not show statistically significant differences in hospital readmission or HRQoL; moreover, confidence in these findings was limited by substantial between-study heterogeneity and the small number of included trials. Among secondary outcomes, SDM-based self-management was associated with a small pooled improvement in self-efficacy, whereas no statistically significant difference was observed for depression. A GRADE-informed narrative appraisal suggested moderate to very low certainty across outcomes; thus, both the pooled improvement in self-efficacy and the nonsignificant findings for clinical outcomes should be interpreted as uncertain and subject to change as new evidence emerges.

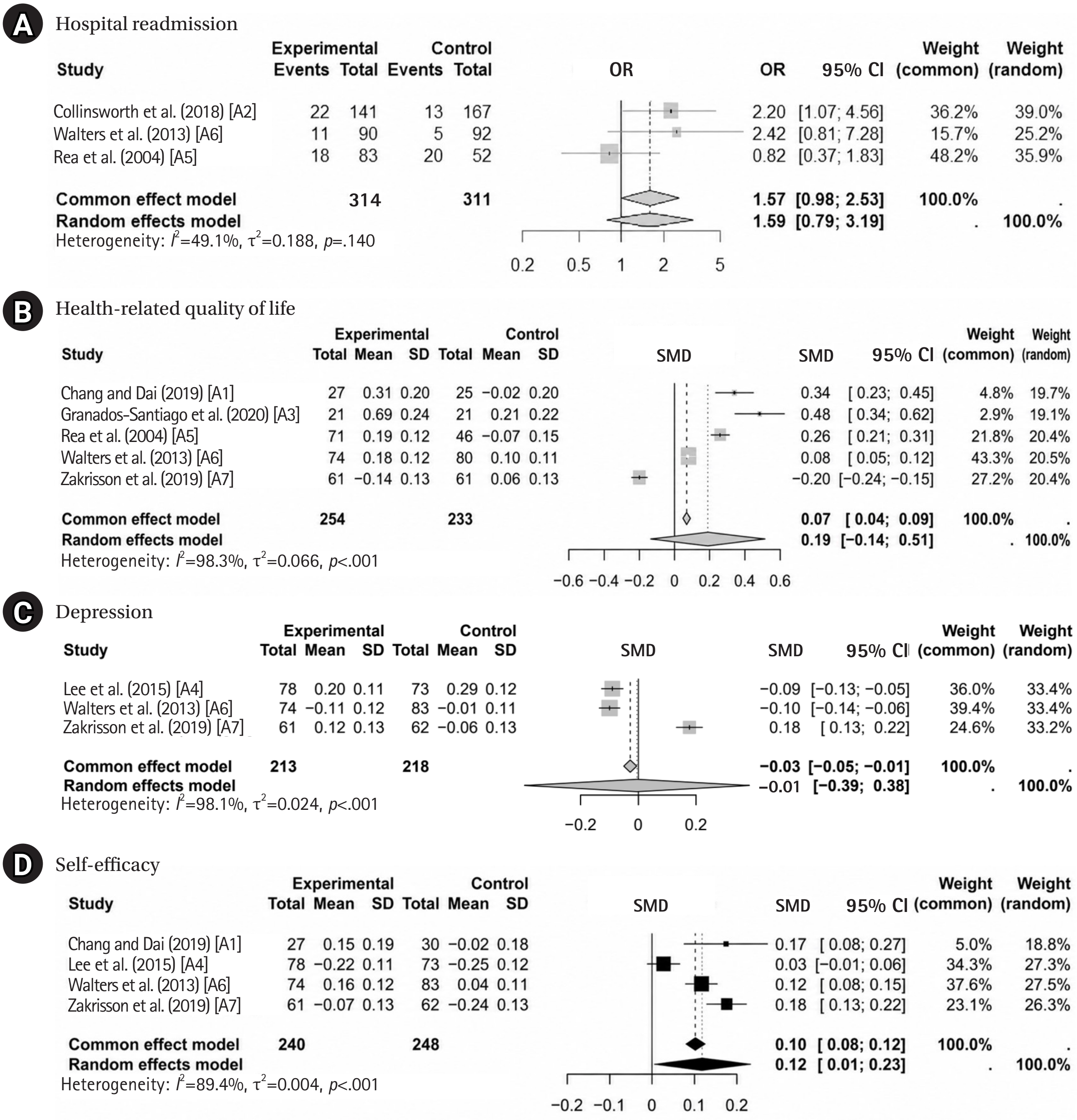


Figure 3. Forest plots of the effects of shared decision-making (SDM)-based self-management interventions. (A) For measuring hospital readmission, the number of readmitted participants in each group was used. (B) For measuring health-related quality of life, COPD Assessment Test was used in A1, EuroQol 5-Dimension was used in A3, the 36-Item Short Form Survey was used in A5, A6, and A7; Chronic Respiratory Disease Questionnaire was used in A5, and St. George's Respiratory Questionnaire and Satisfaction with Life Scale were used in A6. (C) For measuring depression, the Center for Epidemiologic Studies Depression was used in A4 and A6, and the depression subscale of the Hospital Anxiety and Depression Scale was used in A6 and A7. (D) For measuring self-efficacy, the Pulmonary Rehabilitation Adapted Index of self-efficacy was used in A1, the Coping Self-Efficacy Scale was used in A4, the Self-Efficacy to Manage Chronic Disease in A6, and the Exercise Self-Efficacy Scale was used in A7. CI = confidence interval; OR = odds ratio; SD = standard deviation; SMD = standardized mean difference.

Table 2. Random-Effects Meta-Analysis of Shared Decision-Making between Pretest and Posttest

Variables	k	No.	Q	df	*p*-value	I^2 (%)	Effect size OR or SMD (95% CI)	t	*p*-value
Primary outcomes									
Hospital readmission	3	625	3.93	2	.140	49.1	1.59 (0.79 to 3.19)	1.32	.318
HRQoL	5	487	242.20	4	<.001	98.3	0.19 (−0.14 to 0.51)	1.60	.184
Secondary outcomes									
Depression	3	431	105.15	2	<.001	98.1	−0.01 (−0.39 to 0.38)	−0.05	.962
Self-efficacy	4	488	28.31	3	<.001	89.4	0.12 (0.01 to 0.23)	3.37	.043

The Hartung-Knapp adjustment was applied, and the t-test used. df = k–1.
CI = confidence interval; df = degrees of freedom; HRQoL = health-related quality of life; I^2 = inconsistency statistic; k = number of studies; OR = odds ratio; Q = Cochran's Q; SMD = standardized mean difference.

Self-efficacy is a common proximal target of COPD self-management interventions. Prior reviews suggest that self-management programs may improve HRQoL and reduce respiratory-related hospital admissions, although effects vary across intervention components and follow-up periods [6,15]. In this review, SDM-integrated self-management was associated with a small improvement in self-efficacy but no statistically significant differences in hospital readmission or HRQoL. This pattern is consistent with the SDM literature, which indicates more consistent effects on affective-cognitive outcomes than on distal clinical endpoints [19]. One plausible explanation is that SDM strengthens self-efficacy by increasing perceived involvement and autonomy and by supporting behavior change through collaborative goal setting, action planning, and follow-up feedback. These mechanisms are consistent with self-efficacy theory, which emphasizes mastery experiences and verbal persuasion as key sources of efficacy beliefs [30,31]. Future trials should test whether self-efficacy mediates downstream behavioral changes and clinical outcomes in SDM-based COPD self-management.

In the broader context of chronic respiratory disease, Barradell et al. [9] identified eight SDM intervention studies and reported that outcomes were heterogeneous and inconsistently measured across trials, limiting confidence in downstream clinical effects. Although the included studies generally reported improvements in patient decision-making and health-related outcomes, the overall certainty of evidence was limited because of heterogeneity and RoB, and only a subset of interventions addressed patient-, clinician-, and consultation-level components in an integrated manner [9]. Taken together, these findings suggest that downstream clinical effects may be difficult to detect without standardized SDM components and harmonized outcome assessments. This interpretation is consistent with the variability in SDM delivery observed across the included COPD studies, including differences in providers, delivery modes, and intervention duration.

Compared with prior COPD self-management meta-analyses, which primarily evaluated self-management irrespective of explicit SDM components and emphasized hospitalization rates and HRQoL as key outcomes [6,32], this review specifically examined self-management programs that incorporated SDM and assessed SDM implementation using the SHARE framework [12]. The SHARE-based analysis showed that implementation across the included studies was partial and inconsistent; most interventions emphasized later SHARE steps, such as goal setting and follow-up, whereas systematic assessment of patient values or structured presentation of management options in earlier SHARE steps was seldom reported. This pattern likely reflects the challenge of fully applying all SHARE steps within structured intervention trials, in which detailed patient-provider interactions are not always captured. Accordingly, future trials should treat early SHARE steps, including structured presentation of management options and systematic elicitation of patient values and preferences, as required components and should verify fidelity to prespecified SDM components [12,33]. These findings suggest that the lack of clear effects of SDM on clinical outcomes may reflect insufficient integration of essential SDM components within the programs. Given that early SHARE steps were inconsistently implemented, proximal gains may partly reflect later-stage coaching elements, such as goal setting and follow-up, rather than full-spectrum SDM.

Potential sources of heterogeneity should therefore be considered. A key contributor was variability in how outcomes were measured across trials, as several constructs were assessed using different instruments with nonidentical content and responsiveness to change [27]. For example, some studies used both disease-specific and generic instruments to assess patient-reported outcomes, including HRQoL, and some also included a measure of global life satisfaction. Because measurement nonequivalence can inflate between-study variability and limit interpretability, pooled estimates should be interpreted cautiously, with greater emphasis placed on the direction and consistency of effects across individual trials [27]. In addition, differences in follow-up timing, populations, intervention intensity, and SDM implementation likely contributed to heterogeneity. Given the small number of studies per outcome, subgroup analyses and meta-regression were not feasible [27]. Future trials should improve comparability by prespecifying primary instruments for key outcomes, harmonizing outcome definitions, and standardizing assessment time points.

In the final selection of seven studies, quality assessment revealed deficiencies in several areas. Nonblinded outcome assessments and unclear reporting of allocation concealment raised concerns about potential bias, particularly for self-reported outcomes such as self-efficacy and psychological symptoms. Moreover, some studies lacked information on protocol registration or institutional review board approval. Future trials should strengthen randomization procedures; clearly report sequence generation and allocation concealment in accordance with CONSORT guidance [34]; blind outcome assessors whenever possible; and prioritize objective outcome sources, such as hospitalization records or administrative data, to minimize bias in outcome measurement, as emphasized in contemporary RoB guidance for randomized trials [24]. Improving overall study quality through comprehensive documentation of study design and approval processes will contribute to more robust and reliable findings.

This study had several limitations. First, research on SDM in the context of self-management programs for patients with COPD remains in its early stages, resulting in a limited evidence base. Second, one study measured the same construct using multiple instruments. Although these measures were combined into a single weighted mean effect size where feasible, differences in instrument content and responsiveness may have limited comparability. Third, substantial heterogeneity across outcomes likely reflected differences in follow-up duration, intervention delivery, and the extent to which core SDM components were implemented. In addition, incomplete statistical reporting in one study restricted data synthesis. The literature search was conducted in July 2022; therefore, more recent studies may not have been captured. Because few studies were available per outcome, funnel plots and related tests were not performed, and small-study effects, including publication bias, could not be assessed [27].

CONCLUSION

This systematic review and meta-analysis of seven RCTs assessed the effects of SDM-based self-management interventions on primary and secondary outcomes in patients with COPD. The pooled estimates showed no statistically significant differences in hospital readmission or HRQoL, whereas SDM-based self-management was associated with a small pooled improvement in self-efficacy. However, these findings should be interpreted cautiously given the substantial heterogeneity, small number of trials, and moderate to very low certainty of evidence. Future studies should strengthen the rigor of trial design and reporting, standardize outcome assessments, and ensure high-fidelity SDM delivery with consistent implementation and verification of the core SHARE steps.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and/or design acquisition - JYC; analysis - SYL and SYY; interpretation of the data - SYL and SYY; and drafting or critical revision of the manuscript for important intellectual content - JYC and SYY.

FUNDING

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (Grant Number NRF-2022R1A2C1010364).

ACKNOWLEDGEMENT

None.

DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding authors.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2025.1118.

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REVIEW ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 139-154, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2025.1125

KJAN
Korean Journal of
Adult Nursing

Assessing the Proficiency of Emergency and Critical Care Nurses in Electrocardiogram Interpretation and the Integration of Computerized Electrocardiogram Analysis—Benefits and Limitations: A Systematic Review

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Received: November 25, 2025
Revised: April 18, 2026
Accepted: May 4, 2026

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Purpose: This systematic review aimed to evaluate electrocardiogram interpretation competency among emergency and critical care nurses and to examine the diagnostic performance, benefits, and limitations of computerized and artificial intelligence–based electrocardiogram interpretation systems. **Methods:** This systematic review was conducted in accordance with PRISMA 2020 guidelines and registered in the International Prospective Register of Systematic Reviews under registration number CRD420251169307. Six electronic databases and additional sources were searched for studies published between January 2020 and October 2025, with the final search conducted in October 2025. Studies were included if they involved registered nurses interpreting electrocardiograms in acute care settings or evaluated computerized electrocardiogram interpretation systems using adult datasets. Methodological quality was assessed using validated tools appropriate to study design, including the Joanna Briggs Institute critical appraisal tools, ROBINS-I, and QUADAS-2. **Results:** Mean electrocardiogram interpretation scores among nurses ranged from 43% to 68%, with fewer than 40% of participants meeting predefined competency thresholds. Performance was strongest for asystole recognition and weakest for tachyarrhythmias, myocardial ischemia, and conduction abnormalities. Artificial intelligence–based systems demonstrated high diagnostic accuracy, with area under the curve values ranging from 0.91 to 0.97 and sensitivity exceeding 94% across major diagnostic tasks. **Conclusion:** Emergency and critical care nurses demonstrated insufficient electrocardiogram interpretation competency in several safety-critical domains. Computerized and artificial intelligence–based systems showed high diagnostic accuracy and may serve as effective complementary tools when integrated with ongoing nurse education and appropriate clinical oversight.

Key Words: Electrocardiography; Critical care nursing; Emergency nursing; Professional competence; Artificial intelligence

INTRODUCTION

Electrocardiogram (ECG) remains one of the most essential diagnostic tools in emergency and critical care settings, providing real-time information that guides life-saving interventions such as rapid defibrillation, reperfusion therapy, and cardiac pacing in patients with arrhythmias, acute coronary syndrome (ACS), or conduction abnormalities [1,2]. Nurses are often the first healthcare professionals to assess critically ill patients in high-acuity settings, including intensive care units (ICUs) and emergency departments (EDs). Consequently, they are expected to rapidly obtain and accurately interpret ECG findings before physician or cardiology review [3,4].

Nonetheless, growing evidence indicates that nurses' ECG interpretation skills remain inconsistent and frequently inadequate, particularly in identifying life-threatening rhythms such as ventricular tachycardia, ventricular fibrillation, and atrial fibrillation, as well as myocardial ischemia and conduction block [1]. These deficiencies have been associated with limited access to structured training, inconsistent educational support, and the absence of standardized assessment instruments in critical care nursing practice [3,4]. Furthermore, ECG interpretation knowledge and diagnostic accuracy tend to decline without ongoing practice or refresher training, creating a "use-it-or-lose-it" phenomenon that may compromise patient safety during time-sensitive emergencies [5,6].

Simultaneously, computerized ECG interpretation systems using computerized interpretation engines (CIEs) and artificial intelligence (AI)–based algorithms have emerged as potential tools to support frontline clinicians by providing rapid, standardized, and automated ECG analysis [2,6]. Kashou et al. [7] reported that incorporation of computerized ECG interpretation increased overall ECG interpretation accuracy among healthcare professionals by 15.1%. The same study also demonstrated a 10.3% improvement in ventricular rate determination accuracy and a modest 1.9% increase in mean QRS axis interpretation accuracy.

AI has also demonstrated strong performance in arrhythmia detection. For example, AI-based models achieved an area under the curve (AUC) of 0.87 for atrial fibrillation detection [8]. Similarly, the review conducted by Neupane et al. [9] reported that deep learning integration improved ECG interpretation performance and facilitated earlier detection of cardiac abnormalities. However, despite these advances, concerns remain regarding generalizability, algorithmic bias, interpretability, and excessive clinician reliance on AI systems when human ECG interpretation skills are not adequately maintained [1,6].

The central issue therefore lies at the intersection of human expertise and technological advancement. On one hand, nurses in EDs and ICUs demonstrate inconsistent ECG interpretation performance with potentially significant clinical consequences. On the other hand, despite their considerable potential, computerized and AI-based systems cannot yet be relied upon independently because of limitations related to bias, explainability, and generalizability [3,4].

Addressing this issue is important for two major reasons. First, improving nurse competency may help ensure that frontline clinicians retain the ability to identify and respond to critical ECG abnormalities in real time, even in the absence of technological support, thereby reducing the likelihood of delayed or inappropriate treatment [1,5]. Second, the integration of computerized and AI-based ECG interpretation systems as complementary, rather than substitutive, tools may improve diagnostic accuracy, enhance workflow efficiency, and provide an additional safety layer for both novice and experienced clinicians, ultimately improving patient outcomes in emergency and critical care settings [2,6].

Such a dual approach, combining sustained human competency development with responsible technological integration, represents an important strategy for addressing current competency gaps and improving the quality of acute cardiac care internationally [3,4].

For the purposes of this review, competency refers to the ability to correctly interpret ECG findings using standardized assessment tools or predefined performance thresholds. Accuracy refers to the proportion of correct ECG interpretations within a specific diagnostic domain, such as rhythm recognition or ischemia detection, whereas proficiency is used as a broader construct encompassing knowledge, interpretive skill, and applied clinical performance. These terms are used consistently throughout the manuscript to improve conceptual clarity.

Delayed recognition of malignant arrhythmias, misinterpretation of ischemic ST segment and T wave changes, and inaccurate identification of conduction abnormalities have been associated with delayed escalation of care, inappropriate treatment decisions, and increased morbidity risk during acute cardiac emergencies [10]. Observational studies have suggested that missed or incorrectly interpreted ECG findings by frontline nurses may contribute to delayed reperfusion therapy, delayed defibrillation, and prolonged time to definitive cardiac intervention, particularly in resource-limited or high-workload settings [3].

Concurrently, advances in computerized and AI-based

ECG interpretation systems have demonstrated high diagnostic accuracy for arrhythmias, ACSs, and conduction abnormalities under controlled validation conditions [11]. Although these systems provide rapid, standardized, and reproducible ECG analysis, concerns remain regarding their generalizability, potential algorithmic bias, limited explainability, and the risk of clinician over-reliance [9]. Importantly, the existing literature has largely evaluated nurse ECG interpretation competency and AI-based ECG interpretation systems as separate domains, without systematically examining how limitations in human performance align with the strengths and weaknesses of computerized interpretation systems.

Therefore, an important research gap exists in understanding how nurse ECG interpretation proficiency and AI-based ECG interpretation performance intersect within real-world emergency and critical care settings. To our knowledge, no previous systematic review has synthesized evidence from both domains to evaluate whether AI systems can complement, rather than replace, nurse-led ECG interpretation in safety-critical environments. Addressing this gap is essential for informing evidence-based educational strategies, clinical governance, and the responsible integration of AI-supported ECG interpretation into acute care practice.

Accordingly, the aims of this review were to (1) evaluate the level of ECG interpretation competency among emergency and critical care nurses and identify factors associated with performance variation; and (2) synthesize evidence regarding the diagnostic performance, benefits, and limitations of computerized and AI-based ECG interpretation systems. By integrating evidence from both domains, this review seeks to examine the potential role of a complementary human-AI model in improving diagnostic accuracy and patient safety.

METHODS

1. Study Design

The protocol for this review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD420251169307. The protocol specified predetermined outcomes and an analysis plan to enhance methodological transparency and reduce bias. Eligible study designs included cross-sectional studies, cohort studies, before-and-after studies, randomized controlled trials, mixed-methods studies, and quality improvement (QI) projects. For studies of computerized ECG interpretation, clinical validation studies, external test-set analyses, and methodological studies with quantitative diagnostic performance benchmarking were also eligible. The search was limited to studies published between January 2020 and October 2025. This study was reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

2. Eligibility Criteria

This systematic review used the Population, Interventions/Exposures, Comparators, Outcomes, and Study designs (PICOS) framework to define eligibility criteria across two analytical arms.

3. Inclusion Criteria

Arm A included registered nurses working in acute care environments, such as EDs, ICUs, coronary care units (CCUs), and telemetry units. These settings were selected because nurses in these contexts are routinely responsible for frontline ECG interpretation, consistent with previous competency studies conducted across multiple regions. Arm B included computerized ECG interpretation systems, including both traditional rule-based CIEs and machine learning or deep learning platforms evaluated using adult ECG datasets in clinical or realistic testing environments.

For interventions and exposures, Arm A focused on factors influencing nurse ECG interpretation competency, including formal ECG education, clinical experience, continuing professional development, and guideline-based or structured training programs. Arm B focused on exposure to computerized ECG interpretation systems designed to support rhythm recognition, ischemia detection, conduction abnormality analysis, and interval measurement. Comparators for Arm A included educational modalities, clinical units, experience levels, and pre-post training designs. Comparators for Arm B included expert cardiologist interpretation, traditional CIEs, and direct comparisons between human and AI-based interpretations. Table 1 summarizes the eligibility criteria according to PICOS.

4. Exclusion Criteria

For Arm A (nurse ECG interpretation competency), stud-

Table 1. Summary of Eligibility Criteria according to the PICOS Framework

PICOS elements	Arm A	Arm B
Population	Registered nurses working in emergency departments, intensive care units, coronary care units, and telemetry units	Computerized electrocardiogram interpretation systems evaluated using adult electrocardiogram datasets
Interventions/exposures	Formal electrocardiogram education, clinical experience, continuing education, guideline-based or structured training programs	Use of computerized interpretation engines or artificial intelligence platforms for electrocardiogram analysis
Comparators	Standard training versus structured programs; differences by unit, experience level, or pre-post intervention	Expert cardiologist interpretation; traditional computerized engines versus artificial intelligence–based systems
Outcomes	Electrocardiogram interpretation competency, accuracy by diagnostic domain, predictors of performance, training effects	Diagnostic accuracy metrics, interval measurement error, comparison with human interpretation
Study designs	Cross-sectional studies, cohort studies, before-after studies, randomized controlled trials, mixed-methods studies, quality improvement projects	Diagnostic validation studies, external test-set analyses, methodological and performance evaluation studies

Arm A = nurse electrocardiogram interpretation; Arm B = computerized/artificial intelligence electrocardiogram interpretation; PICOS = Population, Interventions/Exposures, Comparators, Outcomes, and Study Designs.

ies were excluded if they did not include registered nurses, did not involve nurses working in acute care environments such as EDs, ICUs, CCUs, or telemetry units, did not report ECG interpretation competency or accuracy, or were not published in English.

For Arm B (computerized and AI-based ECG interpretation systems), studies were excluded if they did not evaluate AI-based or computerized systems for ECG interpretation or were not published in English.

For both arms, studies were excluded if they focused exclusively on pediatric populations; were case reports, narrative reviews, or editorials; evaluated non-ECG cardiac monitoring tools, such as echocardiography; used simulation without measurable ECG interpretation outcomes; or reported insufficient or unavailable data [1,6].

5. Search Strategy and Selection Process

A comprehensive search strategy was developed to identify studies addressing: (1) ECG interpretation competency among emergency and critical care nurses and (2) the diagnostic accuracy, benefits, and limitations of computerized or AI-based ECG interpretation systems. The search strategy combined controlled vocabulary and free-text terms adapted to each database. For the human proficiency arm, the search combined the following terms: (“electrocardiogram” OR “ECG”) AND (nurs*) AND (“emergency” OR “critical care” OR “ICU” OR “CCU”) AND (“competenc*” OR “proficien*” OR “knowledge” OR “skill*”). The search strategy was developed from the study objectives, with key concepts derived from the research question and relevant keywords and synonyms incorporated accordingly.

For the computerized interpretation arm, the strategy included the following terms: (“computer” OR “algorithm” OR “diagnosis” OR “AI” OR “deep learning” OR “CNN”) AND (“ECG” OR “electrocardiogram”) AND (“accuracy” OR “sensitivity” OR “validation”), based on previous reviews and validation studies of computerized ECG interpretation [12-14].

The electronic databases searched were MEDLINE, Embase, CINAHL, Scopus, Cochrane CENTRAL, and IEEE Xplore. Additionally, IEEE Xplore was searched to identify computational studies. Additional sources, including gray literature, doctoral theses, society guidelines, and registered clinical trials, were also searched to minimize publication bias. Supplementary Material provides the detailed search strategy for each database. To ensure comprehensive coverage, the reference lists of included studies and forward citations were hand-searched.

The literature search was limited to studies published between January 2020 and October 2025 to capture contemporary evidence reflecting current nursing education standards, evolving emergency and critical care practice, and rapid advances in AI-based ECG interpretation technologies. Earlier studies were excluded because of substantial changes in ECG training frameworks, digital ECG acquisition, and the emergence of deep learning–based interpretation systems in recent years.

https://doi.org/10.7475/kjan.2025.1125

All records identified through database and register searches and other sources were imported into a reference management system, where automatic and manual deduplication were performed. A total of 723 records were identified, including 670 records from databases and registers and 53 records from other sources, including reference lists, conference abstracts, and gray literature.

After removing 350 duplicate records, 320 records underwent title and abstract screening by two independent reviewers using predefined eligibility criteria. During this stage, 258 records were excluded, and 62 reports were assessed for full-text eligibility. Among records identified from other sources, 47 were excluded after title and abstract screening, and six reports were further assessed for eligibility. Full-text screening resulted in the exclusion of 46 reports because of nonclinical validation (n = 10), algorithm description only (n = 16), lack of focus on ECG interpretation competency (n = 10), or lack of relevance to review outcomes (n = 10). Ultimately, 22 studies met the inclusion criteria and were included in the review. Based on the analytical framework of the review, 16 studies were categorized into Arm A and six studies into Arm B (Table 2).

Table 2. Characteristics of the Included Studies (Arm A and Arm B)

Studies	Country/region	Study arm	Study design	Setting/data source	Population or dataset	Sample size/dataset size	Main outcomes assessed
Ayasreh et al. [4] (2024)	Jordan	Arm A	Cross-sectional	Emergency departments	Emergency nurses	287 Nurses	ECG interpretation competency score; rhythm recognition
Belay et al. [16] (2024)	Ethiopia	Arm A	Cross-sectional	Adult emergency rooms	ER nurses	252 Nurses	ECG interpretation knowledge and practice
Chen et al. [1] (2022)	International	Arm A	Systematic review	Acute care settings	Emergency and critical care nurses	24 Studies	Nurse ECG competency, education effects
Dossel et al. [25] (2021)	Germany	Arm A	Modeling review	Computational ECG models	Simulated and clinical ECGs	N/A	Computer modeling for ECG interpretation
Hasanien et al. [2] (2023)	Jordan	Arm A	Cross-sectional	ED and ICU	Emergency and critical care nurses	210 Nurses	12-lead ECG proficiency and arrhythmia monitoring
Jalal [18] (2024)	Saudi Arabia	Arm A	Cross-sectional	Hospitals	Registered nurses	204 Nurses	ECG monitoring and interpretation competency
Jassim et al. [20] (2023)	Iraq	Arm A	Cross-sectional	Hospitals	Nurses	100 Nurses	ECG knowledge level
Kashou et al. [7] (2023)	USA	Arm A	Observational	Clinical settings	Medical professionals	892 Clinicians	Factors influencing ECG interpretation proficiency
Kim and Yoo [23] (2025)	South Korea	Arm A	Cross-sectional	ER and ICU	Nurses	230 Nurses	ECG confidence and educational needs
Mohammed Ali et al. [21] (2022)	Egypt	Arm A	Quasi-experimental	Hospital units	Nurses	40 Nurses	Effect of ECG guideline on performance
Ng and Christensen [24] (2024)	Australia	Arm A	Cross-sectional	Acute care units	Registered nurses	120 Nurses	ECG rhythm interpretation knowledge
Obied et al. [17] (2024)	Palestine	Arm A	Cross-sectional	Emergency departments	Emergency nurses	266 Nurses	ECG interpretation competency
Qaddumi et al. [19] (2025)	Palestine	Arm A	Cross-sectional	Hospitals	Registered nurses	198 Nurses	ECG interpretation and arrhythmia management

(Continued on the next page)

Table 2. Continued

Studies	Country/ region	Study arm	Study design	Setting/ data source	Population or dataset	Sample size/ dataset size	Main outcomes assessed
Rahimpour et al. [3] (2021)	Iran	Arm A	Comparative cross-sectional	ED and EMS	Nurses and EMS personnel	180 Participants	ECG interpretation accuracy
Singh et al. [6] (2022)	India	Arm A	Systematic review	Acute care	Nurses	18 Studies	ECG interpretation competency
T/Mariam et al. [22] (2024)	Ethiopia	Arm A	Cross-sectional	ED and ICU	Nurses	225 Nurses	ECG knowledge and practice
Fortune et al. [26] (2022)	USA	Arm B	Methodological validation	ECG image digitization	ECG images/ signals	12,000 ECGs	Signal recovery accuracy
Herman et al. [12] (2024)	Europe (multi-country)	Arm B	Validation study	Clinical ECG databases	Adult ECGs	About 930,000 ECGs	AI diagnostic accuracy (AUC, F1, sensitivity)
Husain et al. [27] (2021)	International	Arm B	Technical review	ECG hardware/ software	ECG sensor systems	N/A	ECG interoperability and digital integration
Muzammil et al. [14] (2024)	International	Arm B	AI validation study	Multicenter datasets	Adult ECG datasets	> 500,000 ECGs	AI-based ECG diagnosis performance
Ose et al. [13] (2024)	USA	Arm B	AI review	Clinical ECG systems	AI ECG platforms	N/A	Benefits and limitations of AI ECG interpretation
Reyna et al. [15] (2024)	USA	Arm B	Dataset development	ECG image database	ECG images	67,000 ECG images	Dataset quality and artifact robustness

AI = artificial intelligence; Arm A = nurse electrocardiogram interpretation; Arm B = computerized/artificial intelligence electrocardiogram interpretation; AUC = area under the receiver operating characteristic curve; ECG = electrocardiogram; ED = emergency department; EMS = emergency medical services; ER = emergency room; ICU = intensive care unit; N/A = not applicable.

Inter-rater agreement during title/abstract and full-text screening was high (Cohen's κ = 0.82), indicating strong consistency between reviewers. The study selection process for each arm is presented in Figure 1 in accordance with PRISMA 2020 guidelines.

6. Outcomes of Interest

1) Primary outcomes

The primary outcomes of this systematic review differed by analytical arm.

For Arm A (nurse ECG interpretation competency), primary outcomes included the proportion of nurses classified as competent according to each study's predefined criteria and mean ECG interpretation scores expressed as the percentage of correct responses. Performance was assessed across clinically relevant diagnostic domains, including rhythm recognition, ischemia detection, interval interpretation, and accurate lead placement.

For Arm B (computerized and AI-based ECG interpretation systems), primary outcomes focused on diagnostic performance metrics, including sensitivity, specificity, positive predictive value, negative predictive value, F1-score, and AUC for detection of atrial fibrillation, ventricular tachycardia or fibrillation, ACSs, and conduction abnormalities. Quantitative accuracy of ECG interval measurements was also assessed and reported as absolute measurement error.

2) Secondary outcomes

Secondary outcomes for Arm A included factors associated with nurse ECG interpretation performance, such as educational level, years of clinical experience, workload, prior ECG training exposure, and professional certification. Evidence regarding knowledge retention, skill transfer to clinical practice, and durability of training effects over time was also examined.

For Arm B, secondary outcomes included workflow efficiency, turnaround time for ECG interpretation, influence on clinical decision-making, clinician confidence in system

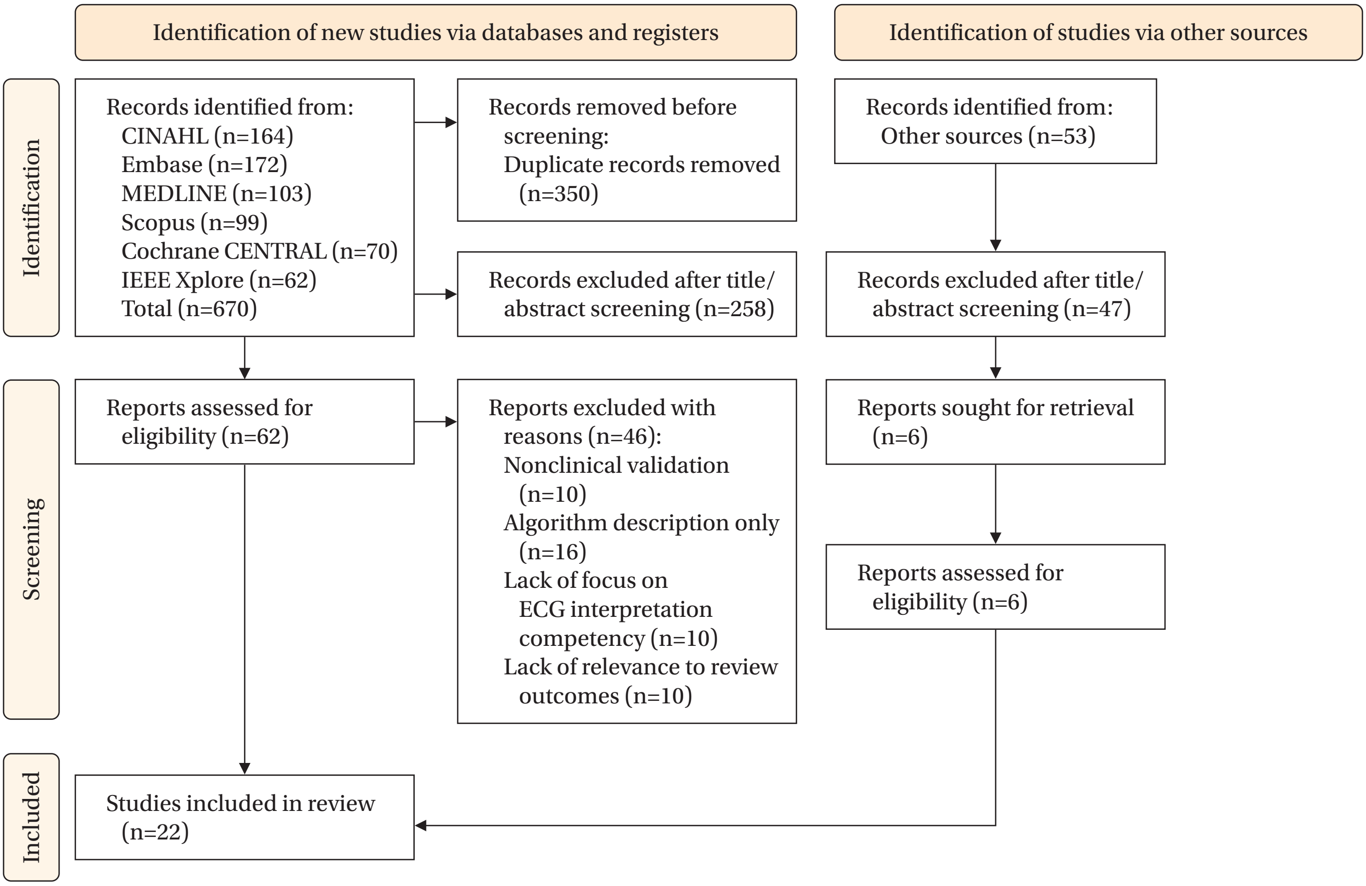

Figure 1. PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) flow diagram. ECG = electrocardiogram.

outputs, potential for misdiagnosis, cost-effectiveness considerations, and issues related to equity, bias, and fairness in algorithmic performance.

7. Risk-of-Bias/Quality Appraisal

Two reviewers independently conducted critical appraisal of each included study using validated instruments appropriate to study design. For cross-sectional and observational studies, the Joanna Briggs Institute critical appraisal checklists and the National Institutes of Health (NIH) Quality Assessment Tool were used. The Cochrane Risk of Bias 2 (RoB 2) tool and the ROBINS-I framework were used to assess randomized controlled trials and controlled before-and-after studies, where applicable. Mixed-methods and QI studies were assessed using the Mixed Methods Appraisal Tool (MMAT) or the Quality Improvement Minimum Quality Criteria Set (QI-MQCS). Studies assessing computerized or AI-based ECG interpretation were appraised using PROBAST-AI and QUADAS-2, with additional consideration of dataset shift, data leakage, ground-truth representativeness, and external validation.

All studies were rated and summarized qualitatively as having low, moderate, or high risk of bias, and disagreements were resolved by consensus. Overall, the appraisal summaries indicated that all 22 studies were of sufficient methodological quality for inclusion in the synthesis, although limitations such as small sample sizes, lack of blinding, and absence of external validation were noted in individual studies (Table 3) [1-4,6,7,12-27]. To ensure consistent and transparent risk-of-bias assessment across Arm A and Arm B, the recommended appraisal tool were used for each study design. Consequently, risk-of-bias results are reported according to the framework of each respective tool.

8. Data Extraction

Two reviewers independently extracted data using a pilot-tested, standardized data extraction form tailored to the two review domains: Arm A, nurse ECG interpretation proficiency; and Arm B, computerized ECG interpretation. For

Table 3. Risk of Bias and Quality Appraisal of Included Studies

Studies	Study design	Appraisal tool	Key appraisal findings	Risk-of-bias judgment	Final decision
Ayasreh et al. [4] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Clear sampling strategy; reliance on self-reported data; no longitudinal follow-up	Moderate	Included
Belay et al. [16] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Multicenter design strengthened validity; recall bias possible; no objective clinical outcomes	Moderate	Included
Chen et al. [1] (2022)	Systematic review	Joanna Briggs Institute systematic review checklist	Comprehensive search strategy; high heterogeneity; some reporting gaps	Low to moderate	Included
Dossel et al. [25] (2021)	Modeling review	QUADAS-2 (adapted)	Strong conceptual framework; no empirical dataset; limited external validation	High	Included (contextual evidence)
Fortune et al. [26] (2022)	Methodological validation study	QUADAS-2	Robust digitization and signal recovery metrics; no direct diagnostic outcomes	Moderate	Included
Hasanien et al. [2] (2023)	Cross-sectional	Joanna Briggs Institute checklist	Standardized assessment tool; single-country setting; modest sample size	Low to moderate	Included
Herman et al. [12] (2024)	Artificial intelligence validation study	PROBAST-AI	Robust external validation; high diagnostic accuracy; potential dataset shift concerns	Low	Included
Husain et al. [27] (2021)	Technical review	QUADAS-2 (adapted)	Comprehensive hardware and software perspective; not focused on diagnostic accuracy	Moderate	Included (technical context)
Jalal [18] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Appropriate sample size; limited validation of competency tool; self-report bias	Moderate	Included
Jassim et al. [20] (2023)	Cross-sectional	Joanna Briggs Institute checklist	Small sample size; basic assessment instrument; no retention assessment	High	Included
Kashou et al. [7] (2023)	Observational study	National Institutes of Health quality assessment tool	Good survey methodology; voluntary participation; limited generalizability	Moderate	Included
Kim and Yoo [23] (2025)	Cross-sectional	Joanna Briggs Institute checklist	Adequate sample size; robust assessment tool; reliance on self-confidence measures	Low to moderate	Included
Mohammed Ali et al. [21] (2022)	Quasi-experimental study	ROBINS-I	Non-randomized design; modest intervention effects; risk of confounding	Moderate to high	Included
Muzammil et al. [14] (2024)	Artificial intelligence validation study	PROBAST-AI	Large and diverse dataset; external validation performed; equity and bias concerns	Low to moderate	Included
Ng and Christensen [24] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Validated test instrument; potential selection bias	Moderate	Included
T/Mariam et al. [22] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Hospital-based sample; moderate size; training exposure insufficiently described	Moderate	Included
Obied et al. [17] (2024)	Cross-sectional	Joanna Briggs Institute checklist	Large sample size; regional focus; limited competency assessment tool	Moderate	Included
Ose et al. [13] (2024)	Artificial intelligence review	QUADAS-2	Comprehensive synthesis; variability in external validation across included studies	Moderate	Included
Qaddumi et al. [19] (2025)	Cross-sectional	Joanna Briggs Institute checklist	Adequate sample size; limited reporting on assessment validity	Moderate	Included
Rahimpour et al. [3] (2021)	Cross-sectional	Joanna Briggs Institute checklist	Nurse versus emergency medical services comparison; self-report bias	Moderate	Included
Reyna et al. [15] (2024)	Methodological dataset development study	QUADAS-2	High-quality dataset; not designed to evaluate diagnostic performance	Moderate	Included
Singh et al. [6] (2022)	Systematic review	Joanna Briggs Institute systematic review checklist	Broad evidence synthesis; substantial methodological variation	Moderate	Included

PROBAST-AI = Prediction Model Risk of Bias Assessment Tool–Artificial Intelligence; QUADAS-2 = Quality Assessment of Diagnostic Accuracy Studies 2; ROBINS-I = Risk of Bias in Non-randomized Studies—of Interventions.

Arm A studies, extracted information included study country, healthcare facility, sample size, nursing cadre, years of experience, prior ECG training exposure, training type and duration, ECG exposure, assessment tools, scoring thresholds, domain-specific scores, predictors of performance, intervention characteristics, and evidence of knowledge or skill retention. Domain-specific scores included rhythm recognition, ischemia detection, interval interpretation, and lead placement.

For Arm B studies, extracted information included system type, categorized as either a traditional CIE or an AI/machine learning system; training and validation datasets; reference standards, such as expert panel review or angiographic confirmation; diagnostic tasks; performance metrics, including sensitivity, specificity, positive predictive value, negative predictive value, F1-score, and AUC; interval measurement errors in milliseconds; external validation; computational runtime; workflow or integration information; bias, fairness, and calibration analyses; and regulatory approval status, where reported. Disagreements between reviewers were resolved through discussion, and cross-verified datasets were extracted accordingly. Although extracted variables differed between Arm A and Arm B, results were synthesized using the most comparable performance measures available, such as accuracy and sensitivity.

9. Data Synthesis and Analysis

Because of substantial heterogeneity in study designs, assessment tools, outcome measures, and performance benchmarks, meta-analysis was not feasible. A structured narrative synthesis was therefore conducted in accordance with PRISMA 2020 recommendations.

For Arm A, results were synthesized by summarizing mean ECG interpretation scores, proportions of participants meeting predefined competency thresholds, domain-specific performance, such as arrhythmia recognition and ischemia detection, and reported predictors of competency. For Arm B, diagnostic performance metrics, including sensitivity, specificity, F1-score, and AUC, were summarized by diagnostic task. Findings were grouped thematically to allow within-arm comparison while avoiding direct quantitative comparison across fundamentally different outcome metrics.

RESULTS

1. Characteristics of Included Studies

The characteristics of the included studies are summarized in Table 2, including study design, setting, population or dataset characteristics, study arm classification, and primary outcomes [1-4,6,7,12-27]. The 22 included articles provided evidence on both nurse ECG interpretation proficiency and computerized ECG interpretation systems. Most nurse-focused studies in Arm A were conducted in the Middle East and Africa, including Jordan (n=2) [2,4], United States (n=1) [7], Saudi Arabia (n=1) [18], Palestine (n=2) [17,19], Iraq (n=1) [20], Egypt (n=1) [21], and Ethiopia (n=2) [16,22]. Additional studies were conducted in Iran (n=1) [3], South Korea (n=1) [23], and Australia (n=1) [24]. One large systematic review included international data [1]. Singh et al. synthesized regional evidence from India [6] and Dossel et al. reviewed computer modeling for ECG interpretation [25]. In contrast, Arm B studies of computerized ECG interpretation had broader geographic representation, including Italy/Belgium/Slovakia/Israel (n=1) [12], studies led by investigators in the United States (n=3) [13,15,26], and a global AI consortium study (n=1) [14]. In terms of design, cross-sectional observational surveys were the most common study type (n=12), followed by systematic or modeling reviews (n=4), methodological or validation studies evaluating AI and computerized interpretation systems (n=5), and one quasi-experimental study (n=1) [23]. Sample sizes varied widely, from 40 nurses in Egypt [21] to 932,711 ECGs used to train AI models in Belgium [12]. Among nurse-centered primary studies, sample sizes ranged from 100 nurses in Iraq [20] to 287 nurses in Jordan [4], with most studies including between 150 and 250 participants. Participants were predominantly ED, ICU, CCU, or telemetry-unit nurses, primarily bachelor's-prepared and often early-career clinicians. Taken together, these studies provide a broad overview of human limitations in ECG interpretation and the capabilities of computerized and AI-assisted systems across diverse healthcare settings.

2. Arm A: Nurse ECG Interpretation Proficiency (Levels and Domains)

Across the 14 nurse-focused studies and two evidence syntheses, overall ECG interpretation competency among emergency and critical care nurses was generally below study-defined competency thresholds. Study-level mean knowledge or skill scores typically ranged from 43% to 68%, and the proportion of nurses classified as competent was usually below 40% when competency was defined using thresholds of 65% to 80% correct responses [1,4,16,18].

The proportion of nurses meeting competency criteria varied by assessment tool and cutoff. For example, 23.5% to 31.0% of emergency nurses in Ethiopia met the excellence threshold of ≥65%, 17.1% of nurses in the West Bank were classified as competent using a cutoff of ≥7.5/10, and 38% of nurses in Iran were classified as competent using the same cutoff. These low-to-moderate competency estimates were consistent with absolute mean scores: emergency nurses in Ethiopia scored 6.82/20 (34%), registered nurses in Australia scored 55% on a 20-item test, nurses in Saudi Arabia achieved 68% knowledge scores despite practice gaps, emergency and intensive care nurses in South Korea scored 13/20 (65%), and nurses in Iraq were categorized as having good, fair, and poor competency in 32%, 44%, and 24% of cases, respectively.

Domain-specific accuracy showed a similar pattern. Recognition of asystole and other readily apparent life-threatening rhythms was relatively stronger, often reaching 70% to 90% accuracy. In contrast, recurrent areas of poor performance included tachyarrhythmias, such as atrial fibrillation, supraventricular tachycardia, ventricular tachycardia, and ventricular fibrillation in some groups; atrioventricular block, particularly high-degree block; ischemia or myocardial infarction reflected by ST-T abnormalities; QT and QRS measurement or correction; axis determination; and accurate precordial lead placement. Many studies reported accuracy below 70% in these domains, with particularly low precision for advanced conduction blocks and myocardial infarction localization. This dispersion was also supported by evidence syntheses. Some ED cohorts demonstrated high rates of correct responses for selected rhythm-knowledge items, exceeding 90%, whereas intensive care and emergency samples showed very low accuracy, below 30%, for malignant ventricular arrhythmias. Differences between knowledge-based performance and practical skills, such as lead placement and interval interpretation, were also common [1,6].

Several factors were associated with higher ECG interpretation scores, including higher educational level, previous ECG coursework, especially face-to-face training lasting more than 20 hours, basic life support or advanced cardiovascular life support certification, ICU or CCU placement, and greater daily ECG exposure. In contrast, total years of clinical experience showed inconsistent or no association with performance. Confidence and recent evidence-seeking behavior were also positively correlated with ECG interpretation performance [17-19,23]. Short-term knowledge gains were reported after interventions such as team-based learning, lecture-discussion sessions, structured modules, and unit-level guidelines; however, without periodic refresher training, knowledge retention declined after the initial post-test period [1,23]. Overall, the evidence addressing Review Question 1 indicates low-to-moderate baseline ECG interpretation proficiency among ED and ICU nurses, with clinically important deficits in safety-critical domains, including tachyarrhythmias, atrioventricular blocks, ischemia, QT and QRS interpretation, and lead placement. These deficits can be modestly improved through structured education but appear to require repeated training and sustained clinical exposure to be maintained [1-4,6,16-19,21-24].

3. Arm B: Computerized/AI ECG Interpretation Performance (Levels and Comparisons)

Across six computerized or AI-focused studies and technology reviews, AI-enabled 12-lead ECG interpretation demonstrated high diagnostic performance across rhythm, ACS, conduction abnormality, ectopy, chamber enlargement, and axis-determination tasks. These systems frequently outperformed traditional CIEs and, in some settings, approached or exceeded expert benchmarks for specific diagnoses [12-15,26,27].

In a large multi-institutional validation study, a deep learning system achieved F1-scores of approximately 0.96 for rhythm interpretation, 0.93 for ACS detection, 0.89 for conduction block detection, 0.97 for ectopy detection, 0.97 for chamber enlargement detection, and 0.90 for axis interpretation. The same system achieved atrial fibrillation sensitivity of approximately 0.95 and specificity of approximately 1.00, with positive and negative predictive values of approximately 0.99. For ST-segment elevation myocardial infarction, sensitivity was approximately 0.99 and the F1-score was approximately 0.95. Interval measurement differences, such as QRS duration +3 msec and QT interval –4 msec, remained within International Electrotechnical Commission tolerance thresholds, indicating robust quantitative agreement [12].

In head-to-head comparisons, the AI system substantially reduced false-negative results compared with a state-of-the-art CIE, including a 41.7% reduction for atrial fibrillation and elimination of false negatives for ST-segment elevation myocardial infarction in the tested subset. The AI system also outperformed CIEs in challenging conduction diagnoses, including left posterior fascicular block and high-degree atrioventricular block [12]. Narrative and quantitative syntheses reported AUCs of approximately 0.91 to 0.97 for arrhythmia and ACS tasks across multiple AI models and datasets. They also reported AUCs of approximately 0.90 to 0.93 for detection of left ventricular ejection fraction ≤35% and credible performance for structural diseases, such as hypertrophic cardiomyopathy and amyloidosis, as well as electrolyte abnormalities. Emerging evidence also supports the potential use of AI-based ECG interpretation for predicting future atrial fibrillation and heart failure, although concerns remain regarding generalizability and bias [13,14].

Foundational enablers of AI-based ECG interpretation include improved data pipelines, such as ECG image digitization methods that achieve high-fidelity signal recovery and support the incorporation of legacy or paper ECGs into modern AI workflows. Artifact-rich paired image-signal datasets also support training and testing for robustness under real-world conditions [15,26]. Systems-level reviews emphasize that advances in sensors, wearable devices, wireless transmission, and standardized data formats may facilitate broader deployment, while also introducing privacy and integration challenges [27].

From the perspective of Review Question 2 the quantitative evidence indicates that AI systems now provide high task-specific accuracy and interval measurements within accepted standards. These systems may therefore serve as reliable adjuncts to human interpretation, particularly in domains where nurse proficiency is weakest, including tachyarrhythmias, atrioventricular blocks, and ACS. However, important limitations remain, including potential dataset shift, algorithmic bias, explainability gaps, and the need for external validation across populations and care pathways before routine, unmonitored use [12-14,20]. Accordingly, the most appropriate implementation strategy is human-AI complementarity: AI should be deployed for high-sensitivity triage and second-reading support, fail-safes should be embedded for critical alerts such as ST-segment elevation myocardial infarction, ventricular tachycardia, ventricular fibrillation, and atrioventricular block, and recurrent nurse education should be maintained to preserve human interpretive competency where AI may be uncertain or where contextual clinical synthesis is essential (Table 4) [1,3,6,12].

4. Integrated Synthesis of the Findings

Integrating findings from both domains indicates that ECG interpretation competency among emergency and critical care nurses is often inadequate, particularly for identifying arrhythmias, atrioventricular block, and ischemic changes. In contrast, AI-based interpretation systems demonstrate high diagnostic accuracy in these domains and generally outperform traditional CIEs. Nevertheless, AI-based systems remain limited by concerns regarding generalizability, potential bias, and explainability.

Collectively, these findings suggest that AI tools may improve ECG interpretation when used as adjuncts to nurse-led assessment. A human-AI approach could enhance diagnostic accuracy in critical care settings while preserving the need for clinical judgment, ongoing education, and appropriate oversight.

DISCUSSION

The results of this review reveal a consistent pattern across the included studies: nurses working in emergency and critical care settings generally demonstrated low-to-moderate ECG interpretation proficiency, whereas computerized and AI-driven systems showed high diagnostic accuracy for several critical cardiac conditions. The nurse-centered evidence indicates that, despite professional expectations for timely ECG interpretation, many nurses did not reach study-defined competency thresholds, with average test scores ranging from the low 40% range to the mid-60% range. These findings are consistent with previous studies [28,29]. Only a small proportion of nurses exceeded the competency standards specified in the included studies [4,16,18,20,24].

Consistent with Buluba et al. [28], the included studies converge on a key finding: nurses demonstrated relatively high accuracy in detecting gross abnormalities, such as asystole, whereas performance declined substantially when they were required to identify tachyarrhythmias, ischemic changes, atrioventricular blocks, and interval abnormalities. This pattern suggests that although more obvious ECG abnormalities may be recognized with reasonable accuracy, subtle and time-sensitive findings remain insuf-

Table 4. Quantitative Synthesis of ECG Interpretation Proficiency (Arm A) and Computerized/AI Systems (Arm B)

Dimension	Arm A (14 primary studies+2 reviews)	Arm B (6 validation and review studies)
Overall performance	Mean interpretation scores: from 43% to 68%. Fewer than 40% of nurses met predefined competency thresholds (typically ≥65%–80% correct). Lowest performance: emergency department nurses in Jordan (about 15% competent; mean score 4.35/10). Highest performance: Iranian emergency departments (about 38% competent).	High diagnostic performance with AUC 0.91–0.97. F1-scores: 0.89–0.97. Sensitivity often above 94%. - Specificity approached 98%–100%, particularly for atrial fibrillation, acute coronary syndromes, and malignant ventricular arrhythmias.
Domain-specific performance	Strengths: Recognition of asystole and gross lethal rhythms (typically ≥70%–90% accuracy). Weaknesses: Tachyarrhythmias atrioventricular blocks, ischemic ST–T changes, interval measurement, and accurate lead placement, often with ≤50% accuracy in multiple cohorts.	Consistent accuracy: arrhythmia detection, acute coronary syndromes, conduction abnormalities, ectopy, chamber enlargement, and axis determination. Small interval errors: interval measurements were small (for example, QRS approximately +3 msec, corrected QT approximately –4 msec), remaining within accepted technical standards.
Education interventions and retention	Structured educational interventions, including team-based learning, guideline-based training, and formal modules, resulted in short-term score improvements of approximately 20%–25%. Score improvement declined over time without refresher training.	No retraining is needed for clinicians. External validation across populations and settings is essential. Accurate in independent test-sets among studies.
Predictors/moderators of performance	Positive predictors: higher educational level, >20-hour ECG courses, professional certification. ICU, CCU placement ECG exposure, and higher self-confidence. Years of general clinical experience showed inconsistent or no association with performance.	Model performance was strongly influenced by dataset size, diversity, and quality of reference standards (expert adjudication or angiographic confirmation). Bias and reduced generalizability were reported when training datasets lacked demographic or clinical diversity.
Human vs. computerized interpretation (head-to-head evidence)	In studies directly comparing performance, nurses demonstrated less than 50% accuracy in ischemia detection and advanced arrhythmia recognition, indicating clinically significant safety gaps in high-risk scenarios.	AI reduced false-negative rates compared with traditional computerized interpretation engines. Including marked reductions for atrial fibrillation. No missed acute coronary syndrome cases in validated studies. Performance was superior for complex conduction abnormalities.
Strengths of evidence base	Multinational, real-world studies. Identification of specific, safety-critical competency gaps relevant to frontline practice.	High diagnostic accuracy across multiple ECG domains; reproducible quantitative performance, scalable and meets technical standards.
Key limitations	Varied methods, mostly cross-sectional studies; limited randomized or longitudinal intervention data. Rare assessment for retention knowledge.	Risk of dataset shift, algorithmic bias, limited explainability, and uneven regulatory approval; most studies conducted in high-income settings, limiting generalizability to low-resource environments.
Implications for review question 1	Baseline ECG interpretation competency among emergency and critical care nurses is low to moderate, with persistent deficits in safety-critical domains. Competency improves with structured education but is not sustained without reinforcement.	AI provides a high-accuracy complementary tool, particularly in domains where human performance is weakest. Optimal practice supports a human-AI partnership with ongoing nurse training and appropriate.

Sensitivity: percentage of true positive correctly identified; Specificity: percentage of true negatives correctly identified.

AI = artificial intelligence; Arm A = nurse electrocardiogram interpretation; Arm B = computerized/artificial intelligence electrocardiogram interpretation; AUC = area under the receiver operating characteristic curve; CCU = coronary care unit; ECG = electrocardiogram; F1-score = harmonic mean of precision and recall; ICU = intensive care unit; QRS = QRS complex; QT = QT interval; ST–T = ST segment and T wave.

ficiently detected, with potentially important implications for patient safety [1,6].

However, findings from studies evaluating computerized and AI-driven ECG interpretation showed a markedly different pattern. Deep learning models demonstrated high sensitivity and specificity for arrhythmias, ACS, and conduction abnormalities, with F1-scores and AUCs generally in the high-performance range [12-14]. These findings are consistent with Ribeiro et al. [30], who reported that AI-driven ECG interpretation outperformed cardiology residents in identifying six types of abnormalities on 12-lead ECG recordings, achieving F1-scores above 80% and specificity greater than 99%.

Errors in interval measurements also remained within acceptable international standards, further supporting the reliability of these systems. AI systems clearly outperformed conventional CIEs, particularly in conditions in which both human interpretation and CIE performance are often weakest, including atrioventricular block, posterior fascicular block, and ST-segment elevation myocardial infarction detection [31,32]. Direct comparisons showed that AI systems reduced false-negative findings and improved detection of life-threatening rhythms [7].

Although AI-based ECG interpretation systems demonstrated high diagnostic accuracy across multiple domains, these findings should be interpreted with caution. Most AI studies used large, curated datasets from high-income healthcare systems, often with expert-annotated reference standards. Variability in ECG acquisition quality, patient demographics, and disease prevalence may affect algorithm performance when these systems are deployed in different clinical contexts. Furthermore, concerns regarding dataset shift, algorithmic bias, and limited explainability underscore the importance of maintaining human oversight and domain expertise [9]. AI systems should therefore be viewed as supportive tools that enhance, rather than replace, clinical judgment.

Van de Leur et al. [32] reported that AI-based ECG interpretation achieved high diagnostic accuracy and reduced cardiologists' ECG-reading workload. Consistent with these findings, this review found that AI-based systems already outperform traditional software and may soon approach, or function as a supplement to, specialist-level interpretation in selected diagnostic tasks [15,25-27].

Comparing the two evidence domains reveals both similarities and differences. Both sets of studies identified tachyarrhythmias and conduction abnormalities as important diagnostic challenges: for nurses, these represented knowledge and skill gaps, whereas for traditional CIEs, they have historically represented areas of weaker performance [3,4,13,14,16]. The key distinction lies in the expected trajectory of improvement. Human performance can improve after educational interventions but may decline rapidly without continued practice or refresher training, whereas AI performance is expected to improve as datasets expand and algorithms advance [1,12,21]. Another similarity is that both domains are vulnerable to limitations in generalizability. Nurse performance varies substantially across countries, institutions, and levels of prior training, whereas AI systems are constrained by dataset representativeness and may perform less reliably in underrepresented populations [13,14,17,19]. Thus, both domains are context-dependent: nurses rely on adequate training systems, and AI systems rely on inclusive datasets and robust validation procedures.

The divergences between the two domains are equally important. Human interpretation is inherently variable and can be influenced by overconfidence, educational background, workload, and clinical exposure, whereas validated AI systems may provide more consistent output under similar input conditions [23,33]. Among nurses, rhythm recognition tends to be stronger than ischemia interpretation, whereas AI systems often maintain high performance across multiple diagnostic domains, including domains in which human performance is weakest [12,18,24]. In addition, although years of clinical experience were not consistently associated with nurse competency, the volume and heterogeneity of training data were important determinants of AI reliability [14,17]. These differences suggest that human interpreters may be more vulnerable to errors in complex pattern recognition, whereas AI systems may excel at pattern detection but remain limited in contextual clinical interpretation.

Taken together, the comparative findings suggest that neither nurse-led ECG interpretation nor AI-based interpretation alone is sufficient to ensure patient safety in emergency and critical care settings. Nurses remain central to clinical decision-making, but current competency gaps may place patients at risk, especially when rapid and accurate interpretation is required. AI-based systems offer a strong adjunctive solution; however, they cannot yet replace human oversight because of concerns regarding trust, explainability, and generalizability [13,25]. The logical implication of this synthesis is a complementary model: nurses should receive standardized ECG education and periodic reassessment to maintain safe competency, while AI systems should serve as high-sensitivity safety nets, particularly in domains where human performance is weakest. This balanced approach acknowledges the limitations of both evidence domains while leveraging their respective strengths to improve diagnostic accuracy, workflow efficiency, and ultimately patient outcomes [1,2,6]. This conclusion is consistent with Kashou et al. [34], who recommended human over-reading to improve diagnostic accuracy.

This review has several strengths. Its dual-arm design synthesized evidence on both nurse ECG interpretation proficiency and computerized or AI-based ECG interpretation, allowing the findings from both domains to be compared and interpreted as potentially complementary. The inclusion of 22 studies from diverse geographic regions strengthens the external relevance of the findings. The methodology was rigorous, with a predefined protocol, duplicate screening, standardized data extraction, and validated risk-of-bias tools selected according to study design. In addition, the inclusion of both conventional clinical studies and recent AI validation studies provides a distinctive synthesis that connects gaps in human performance with the potential role of technological support, offering insights for education, clinical practice, and future research.

This review also has several limitations. Nurse-focused studies were predominantly cross-sectional, used heterogeneous competency assessment tools and thresholds, and included relatively few interventional designs. The rapidly evolving nature of AI research may also limit the long-term generalizability of the findings. In addition, nurse-focused studies were primarily conducted in low- and middle-income countries, whereas AI-based studies largely originated from high-income settings with advanced digital infrastructure, limiting direct comparability between the two evidence domains. Substantial heterogeneity in study design, assessment instruments, outcome measures, and performance thresholds across both arms precluded quantitative pooling and requires cautious interpretation of the synthesized findings.

CONCLUSION

In conclusion, this systematic review found that ECG interpretation competency among emergency and critical care nurses remains variable, with clinically important gaps in safety-critical domains, whereas AI-based ECG interpretation systems demonstrate high diagnostic performance under validated conditions. However, methodological heterogeneity, contextual differences, and implementation challenges limit broad generalization. These findings support a complementary human-AI model that emphasizes ongoing nurse education, structured competency assessment, and cautious integration of AI systems as decision-support tools rather than autonomous diagnostic solutions.

For nursing education, this review highlights the importance of integrating ECG interpretation programs into nursing curricula and maintaining ongoing competency assessment to support patient safety. In clinical practice, AI should be used as an adjunct to, rather than a substitute for, clinical judgment in ECG interpretation.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design acquisition - AHA; data collection - AHA and AAH; analysis and interpretation of the data - AHA; discussion and conclusions - suggestions - AAH; English review – AHA; abstract and references and final submission – AHA; drafting and critical revision of the manuscript – AHA.

FUNDING

None.

ACKNOWLEDGEMENT

None.

DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding authors.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2025.1125.

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REVIEW ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 155-168, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2025.1218

KJAN
Korean Journal of
Adult Nursing

Methodological and Thematic Trends in the *Korean Journal of Adult Nursing* (2015–2024)

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Received: December 18, 2025
Revised: February 11, 2026
Accepted: February 14, 2026

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Purpose: This study analyzed publications from the past decade in the *Korean Journal of Adult Nursing* (KJAN) to examine patterns in research design and thematic trends using both manual coding and topic modeling approaches. **Methods:** A retrospective review was conducted of research articles published in KJAN between 2015 and 2024. Study designs and methodological characteristics were classified using a structured coding framework and analyzed with descriptive statistics. A text-mining approach incorporating keyword network analysis and latent Dirichlet allocation topic modeling was applied to examine thematic patterns. **Results:** Over the past decade, quantitative research was the predominant methodological approach, accounting for more than 70% of the 544 studies. The proportion of qualitative research decreased, whereas literature reviews increased. Within quantitative research, experimental studies declined, while secondary-data analyses and online surveys increased substantially. Keyword and topic analyses consistently highlighted psychological health, quality of life, chronic illness, and older adults as central research domains. Topic modeling further identified five major themes: (1) clinical interventions and symptom management; (2) disease management and health literacy; (3) psychological health, quality of life, and family/social support; (4) health behavior and functional/physical health; and (5) clinical practice, nursing workforce, and work environment. **Conclusion:** Adult nursing research in South Korea demonstrates both continuity and change, with sustained emphasis on psychosocial and chronic illness–related topics and increasing attention to workforce issues. To strengthen future scholarship, greater efforts are needed to ensure that findings derived from diverse research designs are reported in a coherent and integrated manner.

Key Words: Research design; Adult; Nursing; Review; Korea

INTRODUCTION

Analyzing research trends provides insight into the evolution of academic disciplines by revealing shifts in research focus, methodological developments, and emerging topics [1]. Such analyses help scholars and practitioners identify knowledge gaps, inform future research directions, and enhance the relevance of studies to contemporary societal needs [2,3].

The *Korean Journal of Adult Nursing* (KJAN) has played a pivotal role in advancing nursing research in South Korea. Established in 1989 alongside the founding of the Korean Society of Adult Nursing, the journal has contributed substantially to the formalization and expansion of nursing science in South Korea [4,5]. In 2004, KJAN was designated a registered journal by the National Research Foundation of Korea (NRF), further strengthening its academic standing. Its inclusion in internationally recognized databases, including CINAHL and Scopus, in 2011 further enhanced its global visibility and scholarly impact [4,5].

In 2008, KJAN increased its publication frequency to six issues per year, a schedule that continued through 2022 [6]. Beginning in 2023, the journal returned to publishing four issues annually [6]. During the period of expanded publication, KJAN published an average of approximately 70 articles per year, reflecting growth in the volume of adult nursing research. However, alongside this quantitative expansion, evaluating the qualitative advancement of the journal—particularly in terms of scientific rigor and theoretical foundations—has become increasingly important. Moreover, the growing emphasis on interdisciplinary collaboration in the health sciences underscores the need to examine how nursing theories are applied and integrated in studies published in KJAN. Through its relatively high publication frequency compared with other subspecialty journals, KJAN has contributed to the dissemination of high-quality research. By addressing diverse health concerns across adulthood—from acute care to health promotion and mental health [4]—the journal has also supported the advancement of research quality across the broader field of nursing.

Several studies have examined research trends in KJAN. Suh et al. [7] in 2000 conducted an early analysis covering the period from the journal's inception through 2000. Subsequent investigations focused on specific methodological aspects, including quantitative research methodologies and qualitative research methodologies [8,9]. The most recent comprehensive trend analysis was conducted in 2015 and examined articles published between 2010 and 2014 [4]. Since then, no study has systematically evaluated research trends over the subsequent decade (2015–2024), underscoring the need for an updated review. Globally, the COVID-19 pandemic has been associated with a surge in research addressing nurse staffing, mental health, and digital health [10]. Accordingly, analyzing research trends over the past 10 years (2015–2024) allows assessment of whether similar shifts have occurred in KJAN and provides insight into the journal's current position within the broader academic landscape.

Although previous studies provided valuable insight into the general characteristics of research articles published in KJAN, they primarily relied on descriptive analyses of research design, methodologies, and study populations. More recently, studies in nursing and other health care disciplines have adopted advanced analytic approaches, including text network analysis and topic modeling, to examine research trends. These methods enable systematic and objective analysis of large volumes of textual data, facilitating the identification of key themes and relationships among research topics. For example, one study applied these techniques to articles published in the *Journal of Korean Academy of Psychiatric and Mental Health Nursing* between 2013 and 2022, identifying major themes and their evolution over time [11]. In addition, several nursing studies have used text network analysis to assess keyword distributions, co-occurrence patterns, and thematic structures within published research [2,12]. Given the increasing application of these approaches in nursing scholarship, applying them to KJAN offers an opportunity to gain deeper insight into research trends over the past decade.

Therefore, this study aimed to analyze research trends in KJAN over the past decade (2015–2024) by examining the distribution of authors, research designs, study populations, data collection methods, and analytic techniques. In addition, text network analysis and topic modeling were used to examine author-provided keywords and abstracts, providing a comprehensive understanding of prevailing research themes and their interconnections. The application of these methods has expanded within nursing scholarship for the analysis of research topic trends. Through this comprehensive approach, the present study seeks to enhance the methodological rigor and scholarly quality of research published in KJAN, contribute to the development of an independent body of nursing knowledge, and propose strategic directions for the future advancement of adult nursing scholarship and the journal itself.

METHODS

1. Study Design

This study used a retrospective descriptive design to analyze methodological and thematic trends in KJAN from 2015 to 2024. A text-mining approach, including keyword network analysis and latent Dirichlet allocation (LDA) topic modeling, was applied to identify thematic structures. The study is reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

2. Study Subjects

A total of 548 articles were identified from all issues of KJAN published between 2015 and 2024. After exclusion of four retracted articles, 544 articles remained and were included in the final analysis.

3. Study Instruments

A structured codebook was developed to extract and classify the characteristics of each study. The codebook was informed by prior research trend analyses in nursing and included categories for: (1) general study characteristics (authors, study populations, data collection settings); (2) methodological characteristics (quantitative, qualitative, mixed methods, review, and methodological studies); (3) funding status; (4) key research terms; and (5) abstracts. Research design categories included quantitative experimental studies, nonexperimental observational designs, secondary-data analyses, qualitative approaches, and methodological studies. This framework was iteratively refined through coder training and consensus meetings, particularly for studies with ambiguous or underreported methodological details.

4. Data Collection

Data collection, including article retrieval, metadata extraction, and PDF verification, was conducted from February 24 to March 3, 2025. Metadata and keywords extracted via Python-based automation were manually reviewed by two researchers, who cross-checked the outputs against the full-text PDFs.

To classify methodological characteristics, the research team first reviewed prior nursing research trend analyses [3,4,8] and standard nursing research methodology textbooks [13-15] to develop an initial coding framework for research design classification. Using this framework, one researcher performed the primary coding for each article, including: (1) research design classification; (2) purpose-based categorization of quantitative studies; and (3) classification of data collection timing (e.g., cross-sectional, longitudinal, retrospective).

When articles could not be readily classified using the initial guidelines, these cases were discussed with the principal investigator, and classification decisions were made collaboratively. After completion of the initial coding, articles requiring further discussion were re-examined, and the coding guidelines were refined accordingly. The research team then reached consensus on the revised classification framework, which was used to finalize the coding. Because this study used a consensus-based coding approach with a researcher-developed classification framework, rather than independent parallel coding with a standardized instrument, interrater reliability statistics were not calculated.

5. Data Analysis

A multistep analytic approach was used to examine research characteristics and thematic trends. SAS ver. 9.4 (SAS Institute, Cary, NC, USA) was used to calculate frequencies and percentages for research designs, study populations, data collection methods, funding sources, and thesis-related characteristics.

To capture explicit thematic emphases, author-provided keywords were analyzed using frequency statistics. A word cloud was generated in R (ver. 4.5.2), with font size proportional to term frequency, to provide a visual overview of dominant research terms across the decade [16]. To examine structural relationships among research topics, a keyword co-occurrence matrix was constructed, with keywords appearing in the same article considered co-occurring. Using the igraph package ver. 2.2.1 in R (https://igraph.org), a weighted network was created, and community structures were identified using the Louvain clustering algorithm. This approach enabled identification of thematic clusters and relational patterns beyond simple frequency counts. Topic modeling was conducted using LDA to identify the underlying thematic structure of articles published in KJAN from 2015 to 2024. Author-provided keywords and English-language abstracts were used as textual inputs. Text preprocessing included lowercasing, removal of punctuation and numbers, and stopword filtering.

Domain-specific stopword refinement was performed iteratively. First, generic methodological and structural terms (e.g., study, results, participants) were excluded based on prior knowledge because they provide limited discriminative value for identifying substantive research themes. Next, to provide an objective rationale for further refinement, document frequency (DF) was calculated as the percentage of abstracts in which a token appeared at least once. Among high-DF tokens (top 5%), a subset of low-information terms—primarily procedural or reporting-related terms, statistical or modeling-related terms, software-related terms, or generic measurement terms (e.g., analyzed, collected, regression)—was identified. These tokens were added to the domain-specific stopword list to reduce low-information drivers of topic formation. DF-based screening was used as a supplementary criterion rather than a rigid exclusion rule.

Aggressive stemming or lemmatization was not applied to avoid over-normalization and to preserve semantically meaningful distinctions in nursing and clinical terminology [17]. Instead, conservative normalization was applied, and multiword expressions (e.g., quality of life) were retained as compound terms to enhance interpretability. This approach is consistent with prior research indicating that stemming does not necessarily improve—and may even degrade—topic model interpretability [17].

To determine the optimal number of topics, candidate models were evaluated with topic numbers ranging from $k=3$ to 10. Model selection was based on a combination of statistical fit and semantic quality, including perplexity and topic coherence. Although perplexity continued to decrease as k increased, topic coherence and interpretability were maximized at $k=5$. Models with fewer topics ($k\leq4$) tended to merge conceptually distinct research areas, whereas models with more topics ($k\geq6$) yielded fragmented or overlapping topics with reduced interpretability. Based on topic coherence, interpretability, and analytic parsimony, a five-topic model was selected for the final analysis. In the final model, each article was assigned to the topic with the highest posterior probability (γ), and topic distributions were compared across two publication periods (2015–2019 and 2020–2024).

For these analyses, the authors made the following preparations. One author received supplementary training through workshops on big data analysis using R and gained practical experience applying R and Python during the analysis. The research team also included members with prior experience in literature review and content analysis.

RESULTS

1. Study Characteristics

Study characteristics are summarized by period in Table 1. Across the decade, 544 articles were published, with 315 (57.9%) in 2015–2019 and 229 (42.1%) in 2020–2024. Most first authors were affiliated with universities (71.5% overall), although this proportion decreased slightly over time (73.7% to 68.6%), while hospital-based first authors increased from 25.1% to 31.0%. Only a small proportion of papers originated from other institutions (≤1%).

With respect to study populations, adults and older adults were consistently the primary focus. Across all years, 49.8% of studies included adults and 47.1% included older adults, with a greater emphasis on older adults in 2015–2019 (52.7%) than in 2020–2024 (39.3%). Patient-based studies accounted for nearly half of all articles (48.4%), whereas nurse-focused research increased from 13.3% in 2015–2019 to 22.3% in 2020–2024, reaching 17.1% overall. Smaller but non-negligible proportions of studies focused on students (5.3%) or families (4.0%), or were based on document-based studies (10.9%).

Most studies were conducted in clinical environments. Tertiary or university hospitals were the most common setting (37.5% overall), followed by general hospitals (22.1%). Community settings (11.2%), long-term care facilities (5.3%), universities (3.5%), and community or welfare centers (5.3%) were used less frequently. Notably, literature-based studies and those using online communities or websites increased in the latter period: literature as a setting rose from 9.8% to 15.3%, and online or website settings increased from 1.9% to 5.2%. Public health centers were used in only a small proportion of studies (approximately 1.3%), and other settings were rare. Regarding data collection methods, survey designs predominated but declined over time, from 64.1% in 2015–2019 to 45.9% in 2020–2024 (56.4% overall). In contrast, use of online survey panels increased markedly (from 1.3% to 15.3%), reflecting the expansion of web-based data collection. Studies using electronic medical records (EMRs) accounted for approximately one-fifth of articles in both periods (19.1% overall).

In terms of research funding, 71.0% of studies reported no research funding, with similar proportions in both periods. Government grants (including NRF and ministries) supported 14.3% of studies overall, and university funding supported 11.2%, with a modest decline in universi-

Table 1. Study Characteristics by Period (2015–2019 and 2020–2024)

Categories	Classifications	2015–2019	2020–2024	Total
		n (%)	n (%)	n (%)
Total		315 (100)	229 (100)	544 (100)
First author's institution	University	232 (73.7)	157 (68.6)	389 (71.5)
	Hospital	79 (25.1)	71 (31.0)	150 (27.6)
	Others	4 (1.3)	1 (0.4)	5 (0.9)
Subjects	Patients	156 (49.5)	107 (46.7)	263 (48.4)
	Nurses	42 (13.3)	51 (22.3)	93 (17.1)
	Adults	162 (51.4)	109 (47.6)	271 (49.8)
	Older adults	166 (52.7)	90 (39.3)	256 (47.1)
	Students	20 (6.4)	9 (3.9)	29 (5.3)
	Family members	17 (5.4)	5 (2.2)	22 (4.0)
	Research articles	30 (9.5)	29 (12.7)	59 (10.9)
Data collection setting	Tertiary hospital/university hospital	114 (36.2)	90 (39.3)	204 (37.5)
	General hospital/hospital	71 (22.5)	49 (21.4)	120 (22.1)
	Community	31 (9.8)	30 (13.1)	61 (11.2)
	Long-term care	21 (6.7)	8 (3.5)	29 (5.3)
	University	13 (4.1)	6 (2.6)	19 (3.5)
	Online community/website	6 (1.9)	12 (5.2)	18 (3.3)
	Community center/welfare center	21 (6.7)	8 (3.5)	29 (5.3)
	Public health center	4 (1.3)	3 (1.3)	7 (1.3)
	Literature	31 (9.8)	35 (15.3)	66 (12.1)
	Other	8 (2.5)	0 (0)	8 (1.5)
Data collection	Survey	202 (64.1)	105 (45.9)	307 (56.4)
	Online survey	4 (1.3)	35 (15.3)	39 (7.2)
	EMR	64 (20.3)	40 (17.5)	104 (19.1)
Research funding	None	224 (71.1)	162 (70.7)	386 (71.0)
	Governments (NRF, Ministry)	44 (14.0)	34 (14.9)	78 (14.3)
	University	41 (13.0)	20 (8.7)	61 (11.2)
	Other	6 (1.9)	13 (5.7)	19 (3.5)
Thesis	No	177 (56.2)	140 (61.1)	317 (58.3)
	Yes	138 (43.8)	89 (38.9)	227 (41.7)

Percentages are calculated within each period. Some categories may exceed 100% because studies could be classified into multiple subcategories.
EMR = electronic medical record; NRF = National Research Foundation.

ty-funded work in the later period (13.0% to 8.7%). Finally, a substantial proportion of articles originated from theses: overall, 41.7% were thesis-based, although this proportion decreased from 43.8% in 2015–2019 to 38.9% in 2020–2024, suggesting a gradual shift toward non-thesis research outputs.

2. Trend in Research Design and Methodological Characteristics

Table 2 summarizes the methodological characteristics of the reviewed studies across two periods (2015–2019 and 2020–2024). A total of 544 studies were included, with 315 published during 2015–2019 and 229 during 2020–2024.

Quantitative studies accounted for the majority of publications in both periods (73.7% in 2015–2019 and 70.7% in 2020–2024). Qualitative research comprised 8.5% overall and decreased slightly in the later period. Reviews and methodological or instrument-development studies increased modestly over time, rising from 8.6% to 11.4% and from 5.4% to 7.9%, respectively.

Within quantitative studies, nonexperimental observational designs remained dominant (63.5% overall). The proportion of experimental or intervention studies decreased from 23.7% to 14.8% in the later period. Secondary-data analyses increased, particularly studies classified

Table 2. Study Design and Methodological Profiles by Period (2015–2019 and 2020–2024)

Categories	Classifications	2015–2019		2020–2024		Total	
		N	%	N	%	N	%
Total		315	100.0	229	100.0	544	100.0
Research design	Quantitative	232	73.7	162	70.7	394	72.4
	Qualitative	31	9.8	15	6.6	46	8.5
	Mixed methods	3	1.0	2	0.9	5	0.9
	Q methodology	3	1.0	1	0.4	4	0.7
	Review	27	8.6	26	11.4	53	9.7
	Methodological / Instrument	17	5.4	18	7.9	35	6.4
	Other / not classifiable	2	0.6	5	2.2	7	1.3
Quantitative Research (subtotal)		232	100.0	162	100.0	394	100.0
Quantitative Research Methods	Experimental / Intervention	55	23.7	24	14.8	79	20.1
	Non-experimental/Observational	145	62.5	105	64.8	250	63.5
	Non-experimental/Secondary Data Analysis	28	12.1	28	17.3	56	14.2
	Non-experimental/Secondary Analysis	4	1.7	5	3.1	9	2.3
Non-experimental Research (subtotal)		177	100.0	138	100.0	315	100.0
Research purpose	Descriptive study	16	9.0	14	10.1	30	9.5
	Correlational study	151	85.3	118	85.5	269	85.4
	Causal inference study	10	5.6	6	4.3	16	5.1
Time perspective	Cross-sectional	165	93.2	121	87.7	286	90.8
	Multipoint Cross-sectional	1	0.6	6	4.4	7	2.2
	Longitudinal	11	6.2	11	8.0	22	7.0
	Retrospective	5	2.8	10	7.2	15	4.8
	Prospective	6	3.4	1	0.8	7	2.2
Experimental Research (subtotal)		55	100.0	24	100.0	79	100.0
Experimental Design	Randomized controlled trial	5	9.1	8	33.3	13	16.5
	Quasi-experimental (non-randomized)	45	81.8	16	66.7	61	77.2
	Others	5	9.1	0	0	5	6.3
Qualitative Research (subtotal)		31	100.0	15	100.0	46	100.0
Qualitative Research Methods	Phenomenology / Descriptive phenomenology	10	32.3	3	20.0	13	28.3
	Grounded theory	10	32.3	1	6.7	11	23.9
	Ethnography	0	0	1	6.7	1	2.2
	Content analysis	11	35.5	10	66.7	21	45.7

Percentages for subcategories were calculated within each methodological subgroup. Some studies were classified into multiple temporal categories.

as secondary-data analyses (12.1% to 17.3%). Among non-experimental studies, correlational research was overwhelmingly the most common purpose (85.3% in 2015–2019 and 85.5% in 2020–2024). Cross-sectional designs accounted for the majority of studies in both periods (90.8%), indicating a consistent reliance on single-time-point data. Retrospective and longitudinal designs remained relatively uncommon. Experimental studies decreased in frequency over time, from 55 in the earlier period to 24 in the later period. Randomized controlled trials (RCTs) increased proportionally (from 9.1% to 33.3%), although the absolute number remained small. Most experimental studies were quasi-experimental, representing 77.2% overall.

Among qualitative studies, content analysis became more prominent in the later period (35.5% to 66.7%). Phenomenology and grounded theory were more common in earlier years but declined in more recent publications. Ethnographic research remained rare across both periods.

3. Keyword Trends Based on Word Cloud Visualization

The word cloud for 2015–2019 demonstrated clear thematic concentrations in adult nursing research (Figure 1A). The most visually prominent terms included quality of life, depression, aged, nurses, and social support, reflecting

Figure 1. Word clouds of author keywords in *Korean Journal of Adult Nursing* (KJAN) across three periods (2015–2019 [A], 2020–2024 [B], 2015–2024 [C]). The word clouds illustrate the most frequently occurring author-provided keywords across three publication periods. Larger text indicates higher keyword frequency.

strong scholarly attention to psychosocial well-being and gerontological care. Keywords such as anxiety, sleep, exercise, self-care, and self-efficacy also appeared frequently, suggesting sustained interest in psychological health and health-promoting behaviors. In addition, terms related to chronic illness management, including stroke, hemodialysis, and dementia, formed notable clusters, indicating ongoing engagement with populations requiring long-term and intensive care.

The word cloud for 2020–2024 revealed both continuity and emerging themes (Figure 1B). While quality of life, nurses, and aged remained dominant, COVID-19 became one of the largest and most salient terms, highlighting the pandemic's substantial impact on research priorities during this period. Closely related concepts such as intensive care units, delirium, patient safety, and heart failure also featured prominently, indicating increased focus on acute care, critical care environments, and pandemic-related clinical challenges. Psychological and behavioral constructs, including depression, anxiety, self-care, and self-efficacy, continued to appear frequently, reflecting sustained attention to mental health and patient self-management.

The aggregated word cloud for the full decade displayed considerable thematic stability (Figure 1C). Quality of life was the most prominent term overall, followed by nurses, aged, depression, and social support. This pattern underscores sustained emphasis on psychosocial outcomes, nursing workforce, and patient interactions, and the health of older adults. Additional clusters related to chronic conditions (stroke, renal dialysis, coronary artery disease), psychological health (fatigue, sleep, resilience), and health behaviors (health behavior, exercise, self-care) further illustrate the central focus areas that shaped adult nursing research during the past 10 years.

4. Keyword Structure Analysis: Network Visualization and Centrality Measures

The keyword co-occurrence network for 2015–2024 revealed the overall thematic structure of research published in the journal (Figure 2). The network comprised densely connected clusters as well as peripheral nodes with fewer linkages. Larger nodes represent higher-frequency keywords, whereas thicker edges indicate stronger co-occurrence relationships. Several thematic clusters were visually identifiable, including groups related to mental health (e.g., depression, anxiety, social support), chronic illness and

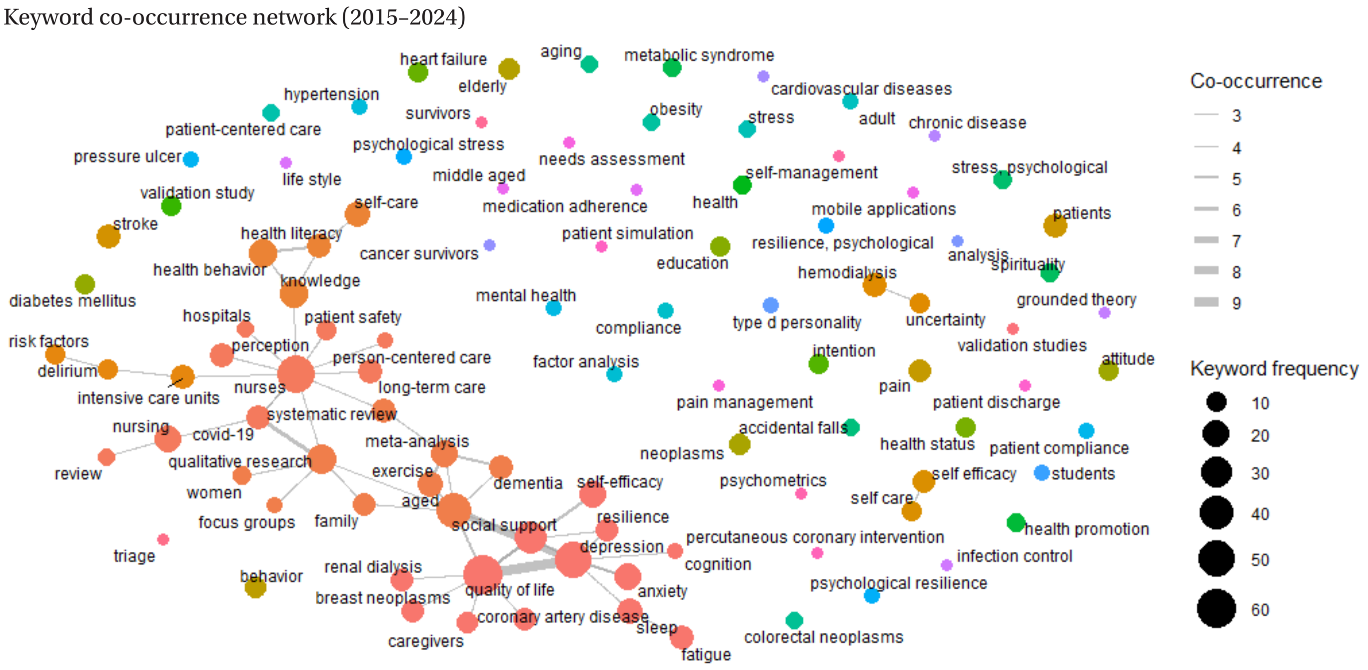

Figure 2. Mapping research trends: a keyword co-occurrence network (2015–2024).

older adults (e.g., aged, dementia, quality of life), and clinical practice topics (e.g., patient safety, nurses, person-centered care). The network exhibited a moderately interconnected structure, with some highly frequent keywords functioning as hubs that bridged multiple research areas. In contrast, many keywords appeared as isolated or weakly connected nodes, suggesting topic-specific or emerging research interests. Overall, the visualization indicates that although research topics were diverse, a few central themes—particularly quality of life, nursing practice, psychological outcomes, and chronic disease—served as major connecting axes within the field.

Network centrality analysis further highlighted the structural importance of several keywords within the co-occurrence network (Supplementary Table 1). Quality of life and nurses showed the highest degree centrality, indicating that these terms were connected to the largest number of other keywords and functioned as network hubs. Depression and aged also demonstrated high degree and closeness centrality, suggesting that mental health and older adult populations were embedded across diverse research topics. In terms of betweenness centrality, nurses, quality of life, knowledge, and social support frequently acted as bridges linking otherwise distant keyword clusters. This pattern suggests that studies focusing on nurses' roles and patients' quality of life often integrated multiple domains, such as psychological outcomes, self-management, and health behaviors. Keywords related to psychological constructs, including anxiety, self-efficacy, and health behavior, also ranked highly across centrality measures, underscoring their cross-cutting relevance in adult nursing research published in KJAN over the past decade.

5. Topic Modeling Analysis

Topic modeling of 544 abstracts published in KJAN between 2015 and 2024 identified five major thematic domains: (1) clinical interventions and symptom management, (2) disease management and health literacy, (3) psychological health, quality of life, and family/social support, (4) health behavior and functional/physical health, and (5) clinical practice, nursing workforce, and work environment (Figure 3, Supplementary Table 2). These topics reflect a coherent structure of adult nursing scholarship encompassing clinical, psychosocial, behavioral, and practice-focused research. Based on posterior topic assignments, the overall distribution showed that psychological health and quality of life research was the most prevalent across the decade (24.8%), followed by research on clinical practice, the nursing workforce, and the work environment (21.9%), reflecting sustained emphasis on mental health outcomes and system-level pressures within adult nursing.

Meaningful temporal differences emerged between 2015–2019 and 2020–2024. From 2015 to 2019, research

https://doi.org/10.7475/kjan.2025.1218

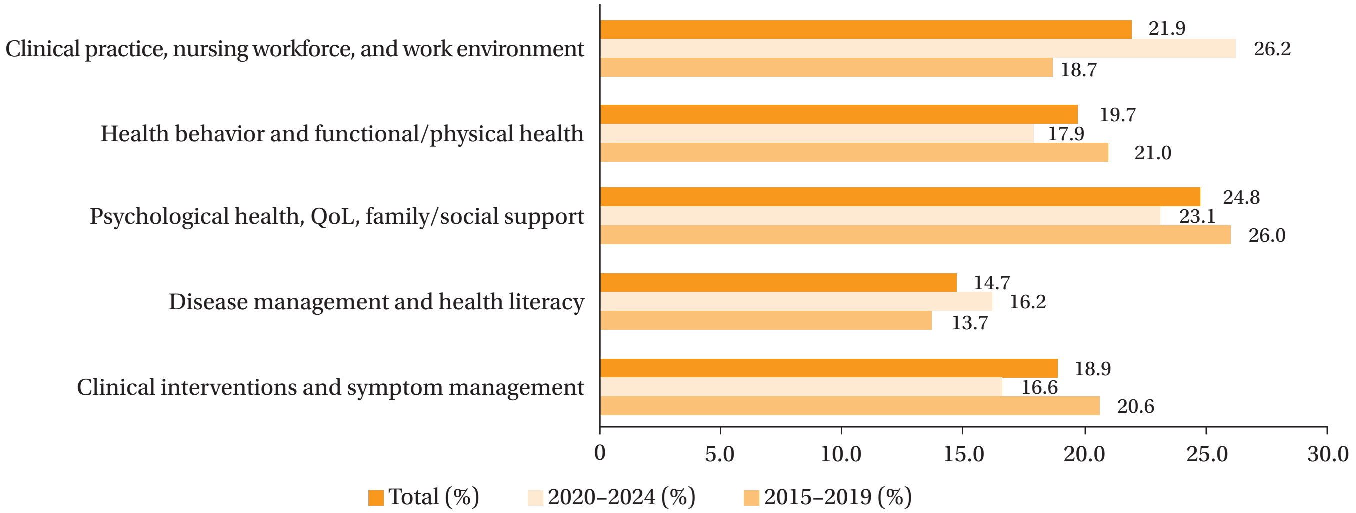

Figure 3. Trend in research topics in *Korean Journal of Adult Nursing* papers across two periods (2015–2019 vs. 2020–2024). Percentages were calculated within each period based on the total number of articles published. QoL = quality of life.

was dominated by psychological health, quality of life, and social support (26.0%), followed by health behavior and functional/physical health (21.0%) and clinical interventions and symptom management (20.6%). In contrast, during 2020–2024, clinical practice, nursing workforce, and work environment became the most prominent domain (26.2%), indicating a shift toward workforce resilience, staffing conditions, and clinical practice environments—patterns aligned with the heightened demands and disruptions associated with the COVID-19 pandemic. While psychological health research remained substantial (23.1%), health behavior and clinical intervention topics showed modest declines, possibly reflecting reduced feasibility of patient-facing studies during pandemic-related restrictions.

DISCUSSION

1. Research Design and Topic Trends and Their Implications

The findings of this study indicate both continuity and change in the methodological and thematic patterns of research published in KJAN over the past decade. Quantitative designs, particularly nonexperimental and cross-sectional studies, remained dominant in both periods, continuing a pattern reported in earlier analyses of South Korean nursing research [3,4,7,8,18]. Most quantitative studies used a cross-sectional design. The proportion of experimental research decreased, and among longitudinal studies, retrospective designs were comparatively common. These patterns highlight persistent structural and practical challenges in conducting intervention and longitudinal research within South Korean nursing contexts. The observed increases in reviews and instrument-development studies suggest that research designs are diversifying beyond traditional approaches. Notably, the proportional increase in RCTs, despite an overall decline in experimental studies, can be viewed favorably. Park et al. [19] in 2025 analyzed research trends in *Journal of Korean Academy of Nursing* (JKAN) and leading international nursing journals over the past decade and reported a predominance of cross-sectional studies in JKAN, a marked decrease in experimental studies, and modest increases in reviews and instrument-development studies; these observations are consistent with the present findings. In contrast, international journals exhibited different patterns: the *International Journal of Nursing Studies* published a high proportion of reviews, including systematic reviews and meta-analyses, as well as experimental studies, whereas the *Journal of Advanced Nursing* published a large proportion of qualitative studies and evidence syntheses. Given that systematic reviews, meta-analyses, and RCTs generally provide higher levels of evidence, KJAN should continue to encourage submissions using these rigorous designs to strengthen the evidentiary base of South Korean nursing research.

A notable methodological transition during this decade was the increase in secondary-data analyses, particularly in the later period. This shift reflects broader trends in

South Korean health sciences, where national datasets, EMRs, and large-scale online survey panels have become more accessible. EMR-based research remained stable at approximately one-fifth of publications, underscoring the growing role of digital data sources in adult nursing research. At the same time, the sharp increase in online survey use after 2020 represents a clear departure from earlier years, when most studies relied on in-person or paper-based surveys. This change is consistent with the digital acceleration associated with the COVID-19 pandemic and the broader adoption of web-based data collection in health research [20,21].

Study population patterns also shifted meaningfully. While adults and older adults remained the primary focus of KJAN publications, studies involving older adults decreased in the later period, whereas nurse-focused studies increased substantially. This transition reflects national and global concerns regarding the nursing workforce, burnout, turnover intention, and organizational climate—issues that gained particular urgency during and after the pandemic. Although earlier reviews of South Korean nursing journals did not specifically emphasize psychosocial or behavioral constructs as dominant domains, visual keyword analyses in recent trend studies indicate that themes such as quality of life, depression, anxiety, dementia, and self-efficacy have consistently appeared as major foci across leading journals [18]. These psychosocial concepts have remained central to South Korean nursing scholarship for more than a decade, forming a stable foundation for inquiry across clinical, community, and aging-related research. Our findings indicate that these psychosocial themes remain prominent in adult nursing research and increasingly intersect with workforce-related topics, such as burnout, patient safety, and organizational climate, that gained importance during and after the COVID-19 pandemic.

The convergence of keyword visualization, network centrality analysis, and topic modeling confirms the persistence of psychological health, quality of life, chronic illness, and gerontology as foundational domains in adult nursing research. This pattern is consistent with prior bibliometric and trend analyses of South Korean nursing and health science literature, which similarly identified quality of life, depression, anxiety, aging, and chronic disease management as enduring core themes [4,18].

Text network analysis and topic modeling use large datasets to quantify contextual word meanings and relationships among terms. These methods enable the extraction of core concepts from the literature, visualization of relationships among concepts, and assessment of the influence of derived concepts [22]. Text network analysis provides an objective representation of relationships among strongly associated keywords by visualizing large-scale textual data [23]. Topic modeling uses probabilistic algorithms to infer latent thematic structures from extensive text data, facilitating the identification of coherent topic groupings and the generation of research insights [24]. Topic modeling results further clarify how the thematic landscape of KJAN research evolved over the past decade. Five dominant themes were identified: clinical interventions and symptom management, disease management and health literacy, psychological health and quality of life, health behavior and functional health, and nursing workforce and work environment. Psychological and quality of life–related research remained consistently central, including studies addressing depression, anxiety, caregiver burden, and resilience among adults with chronic illness. Research on health behaviors and functional status also maintained stable representation, including studies examining lifestyle modification, physical activity, and functional decline in older adults.

The topic modeling analysis also showed a marked increase in studies related to the nursing workforce and practice environment after 2020, indicating a substantive shift in the thematic structure of adult nursing research published in KJAN. Importantly, this trend likely reflects not only increased attention to workforce management but also a broader reconceptualization of workforce issues as integral to adult nursing practice and patient outcomes.

In adult nursing contexts, nurses play a central role in the ongoing management of patients with complex, chronic, and high-acuity conditions. Consequently, staffing adequacy, clinical expertise, workload, and work environments function not as peripheral organizational factors but as core conditions shaping the quality and safety of patient care. The prominence of the nursing workforce topic in KJAN suggests that recent research increasingly frames nurses' working conditions, burnout, and professional roles as determinants of adult patient outcomes, rather than as background system-level variables. The COVID-19 pandemic was a critical catalyst that amplified these concerns. During this period, adult nursing practice was characterized by unprecedented workload intensity, expanded clinical responsibilities, and sustained exposure to high-risk environments. Accordingly, research attention shifted toward nurse burnout, turnover intention, staffing instability, and practice environments, which became highly visible threats to the continuity and quality of adult patient care. International studies have similarly described the pandemic's role in accelerating scholarly focus on nursing workforce sustainability and its implications for patient safety and care quality [25-27].

Notably, the increased prominence of nursing workforce-related topics does not suggest reduced importance of clinical or psychosocial research in adult nursing. Rather, it indicates an integrative shift in which workforce conditions are increasingly examined as foundational contexts within which clinical interventions, symptom management, and psychosocial care are delivered. This interpretation is supported by recent topic modeling and bibliometric studies of major nursing journals, which similarly identified practice environments, job satisfaction, and burnout as cross-cutting themes intersecting with clinical and chronic disease management research [28].

Taken together, the increasing emphasis on nursing workforce issues in KJAN reflects global research trends and the clinical realities of adult nursing in South Korea. As adult patients present with increasing clinical complexity and long-term care needs, understanding and addressing workforce-related factors have become essential for advancing evidence-based adult nursing practice.

2. Recommendations for Improving Research Design Reporting

During the coding process, substantial inconsistency was observed in how research designs were labeled across studies, highlighting the need for greater standardization of design terminology within nursing research. In nonexperimental studies, authors used different criteria to describe the same design structure: some emphasized the timing of data collection using terms such as cross-sectional, longitudinal, or retrospective, whereas others focused primarily on research purpose using labels such as descriptive or correlational. Nursing research methodology textbooks classify research designs along multiple dimensions, including research purpose, temporal orientation, data collection timing, and sampling approach, suggesting that a more integrated approach to design labeling would improve clarity [13-15]. Combining purpose and timing—for example, cross-sectional descriptive study, longitudinal correlational study, or retrospective causal inference study—would allow readers to more accurately understand the structural characteristics of the design.

Several studies classified as secondary analyses did not clearly report essential dataset information, including the dataset name, the organization responsible for data collection, the year of original data collection, and whether the dataset had been used in prior publications. This limitation reduces interpretability and undermines methodological transparency. Consistent with recommendations in the literature, secondary analyses should explicitly describe the origin, purpose, and structure of the primary dataset [14,29,30]. Such reporting enables readers to evaluate the appropriateness of the research design, sampling strategy, and analytic approach. A related issue concerns ethical reporting of secondary analyses: identifying the dataset name, the institution or organization that originally collected the data, the year(s) of data collection, and prior use in published studies provides essential context for evaluating design and analytic appropriateness.

Clearer and more standardized reporting of secondary data use would strengthen methodological transparency across studies. In several papers reviewed, essential dataset information—such as the dataset name, the organization or institution responsible for initial collection, the year(s) of data collection, and prior use in published studies—was not explicitly stated, limiting readers' ability to assess the suitability of the data for the stated research aims. To address this gap, researchers conducting secondary analyses should describe the origin, context, and structure of the primary dataset. Practical examples include specifying that a study is “a secondary-data analysis using [dataset name] collected by [agency] in [year]” or “a secondary analysis of data originally collected by the authors in [year] for a previous study on [topic].” For studies using EMR data, additional clarity is warranted, such as specifying that the analysis used “EMR data extracted from [hospital or medical center] between [start year] and [end year].” These templates allow readers to evaluate sampling, data provenance, and potential biases, thereby improving the interpretability and rigor of secondary-data research.

In addition to reporting the provenance of secondary datasets, studies should clearly specify the underlying research design. Use of secondary data does not replace the need to indicate whether the study used a cross-sectional correlational design, a longitudinal cohort design, or another methodological structure. Reporting both elements—for example, “a cross-sectional correlational study using secondary data from [dataset name] collected by [agency] in [year]"—improves clarity because research design and secondary data use carry distinct methodological implications. Explicit reporting of both aspects allows readers to evaluate alignment between the dataset and the stated aims, assess temporal assumptions, and identify potential biases inherent in secondary-data research.

This review has several limitations. First, because the analysis focused solely on articles published in a single journal, the findings may not fully represent broader trends in South Korean nursing research. Second, keyword and topic modeling analyses were based on abstracts and author-provided keywords, which may not capture the full content of each study; therefore, the findings should be interpreted as approximate thematic patterns. Finally, temporal comparisons between the two periods were descriptive rather than inferential, and the study did not assess methodological quality within individual articles. These limitations should be considered when interpreting the trends identified in this review.

CONCLUSION

This review provides a comprehensive picture of methodological and thematic developments in KJAN over the past decade. While nonexperimental designs and psychosocial themes remained foundational elements of adult nursing research, recent years showed a marked rise in secondary-data analyses and topics related to clinical practice and nurses' work. The shift toward digital data sources and the influence of the COVID-19 pandemic were evident in changing research priorities and methods. Improving the clarity and consistency of research design reporting, particularly in secondary data studies, remains an essential step for advancing the rigor and transparency of South Korean nursing scholarship. Taken together, these findings offer direction for future adult nursing research and highlight the evolving landscape of health, illness, and workforce challenges faced by nurses and the populations they serve.

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CONFLICTS OF INTEREST

Jeonghyun Cho served as the Editor-in-Chief of the *Korean Journal of Adult Nursing* from 2024 to 2025. She was not involved in the review process for this manuscript. Otherwise, there were no conflicts of interest.

AUTHORSHIP

Study conception and/or design acquisition - EP, JL, and JSK; analysis - EP and JSK; interpretation of the data – EP, JHK, JSK, HMS, JC, and BP; and drafting or critical revision of the manuscript for important intellectual content - EP, JL, JHK, JSK, HMS, JC, and BP.

FUNDING

This research was supported by the 2026 scientific promotion funded by Jeju National University.

ACKNOWLEDGEMENT

None.

DATA AVAILABILITY STATEMENT

No new data were created or analyzed during this study. Data sharing is not applicable to this article.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2025.1218.

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ORIGINAL ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 169-181, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2026.0101

KJAN
Korean Journal of
Adult Nursing

Readiness, Attitudes, and Behavioral Intention toward Artificial Intelligence among Clinical Nurses: A Cross-Sectional Study

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Received: January 1, 2026
Revised: March 8, 2026
Accepted: April 8, 2026

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Purpose: This study examined the relationships among nurses' readiness for artificial intelligence (AI), attitudes toward AI, and behavioral intention to use AI, focusing on clinical nurses in a tertiary hospital setting. **Methods:** A cross-sectional descriptive study was conducted using an online self-report survey of 218 clinical nurses recruited through convenience sampling from a tertiary hospital in South Korea. AI readiness was measured using the Medical Artificial Intelligence Readiness Scale, attitudes toward AI were assessed using the Korean version of the General Attitudes toward Artificial Intelligence Scale, and behavioral intention was measured using items adapted from the Unified Theory of Acceptance and Use of Technology. Open-ended responses were summarized descriptively to explore expected AI applications. **Results:** Clinical nurses demonstrated varying levels of AI readiness, attitudes toward AI, and behavioral intention to use AI, and these variables were positively correlated. Among AI readiness dimensions, ability and ethics tended to show stronger bivariate correlations with behavioral intention than vision. Hierarchical regression analysis indicated that attitudes toward AI were strongly associated with behavioral intention ($\beta = .61$, $p < .001$), whereas AI readiness factors showed weaker associations after attitudes were included. Open-ended responses suggested potential AI applications in both direct and indirect nursing care. **Conclusion:** Attitudes toward AI were strongly associated with nurses' behavioral intention to use AI. AI readiness dimensions, particularly ability and ethics, were also associated with behavioral intention in correlation analyses, underscoring the importance of practical competence and ethical awareness. These findings provide empirical evidence to inform AI-related education, clinical integration, and organizational support strategies in nursing.

Key Words: Artificial intelligence; Nurses; Health knowledge, attitudes, practice; Professional competence; Hospitals, teaching

INTRODUCTION

Artificial intelligence (AI) is increasingly being integrated into healthcare, including applications in diagnosis, prognosis prediction, image analysis, and personalized treatment planning [1,2]. In nursing practice, AI has demonstrated potential in areas such as patient monitoring, clinical decision support, and automated documentation [3-5], raising both expectations and concerns regarding changes in professional roles [6] and ethical responsibilities [7-9]. Although international guidelines, including those from the International Council of Nurses, emphasize strengthening nurses' digital competencies and AI-related education [10,11], as well as establishing ethical frameworks for AI [12], the successful and safe implementation of AI ultimately depends on how clinical nurses perceive, prepare for, and engage with these technologies in real-world practice.

Research on AI in nursing has expanded rapidly in recent years; however, many studies have primarily focused on attitudes toward AI and intention to use AI in educational contexts involving nursing students [13-15]. Studies involving clinical nurses have gradually emerged and generally report positive perceptions of AI's potential, alongside concerns regarding ethical issues and its impact on nursing practice [3,16,17]. Additionally, education level and technological experience have been identified as factors associated with attitudes toward AI and intention to use AI [14,17,18]. Among studies conducted in clinical settings, some have examined levels of awareness and attitudes [19], and one study involving intensive care unit nurses explored the relationship between acceptance and readiness for AI [20]. Nevertheless, these studies have often been limited to specific countries or clinical departments.

More recently, research has expanded to include topics such as attitudes and competencies, acceptance of organizational change, and experiences with generative AI across diverse populations, including clinical nurses [21-24]. Previous studies have reported associations between nurses' attitudes toward AI and their self-efficacy and clinical reasoning competence [21], as well as differences in readiness and acceptance according to job category and education level [22,24]. Experiences with generative AI have also been associated with more favorable attitudes toward AI and greater intention to use AI [23]. However, despite this growing body of research, many studies have continued to rely on educational settings or community-based surveys [13,15,21,25-27], which may not adequately reflect the experiences of nurses providing direct patient care in clinical environments.

Nurses, as frontline providers of patient care, are key agents in determining the success or failure of AI implementation and, as producers of clinical data and information records, influence AI performance and patient safety [1,2]. Therefore, clinical nurses' AI readiness and attitudes should be regarded as essential factors for ensuring the safe and effective use of AI in practice, rather than merely reflecting levels of perception. Nevertheless, empirical studies that comprehensively examine readiness, attitudes, and intention to use AI remain limited.

From a theoretical perspective, this study is grounded in the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), which conceptualize attitudes as a proximal determinant of behavioral intention toward technology use [28,29]. Within this framework, readiness-related factors—including perceived ability, ethical awareness, and contextual understanding of AI—are assumed to be conceptually related to nurses' evaluative attitudes toward AI. Attitudes toward AI are, in turn, associated with behavioral intention. Accordingly, attitudes may function as a key conceptual link between AI readiness and behavioral intention in clinical nursing practice. This framework guided the simultaneous examination of AI readiness, attitudes toward AI, and behavioral intention in the present study.

Therefore, this study examined AI readiness, attitudes toward AI, and behavioral intention to use AI among clinical nurses in a tertiary hospital in South Korea. Specifically, the study aimed to (1) assess levels of AI readiness and attitudes toward AI, (2) examine correlations among AI readiness, attitudes, and behavioral intention, and (3) identify factors associated with behavioral intention using hierarchical regression analysis. In addition, open-ended responses were analyzed to identify expected areas of AI utilization in clinical nursing practice that may not be fully captured through quantitative measures.

METHODS

1. Study Design

This was a cross-sectional descriptive correlational study. The study is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

2. Setting and Samples

Participants were clinical nurses with at least 1 year of work experience at a tertiary hospital in South Korea. Eligible participants were licensed nurses currently working in clinical departments who had provided direct patient care for at least 1 year. Nurses who were on leave or had resigned, those not engaged in clinical duties, those working exclusively in research or education roles, and those with less than 1 year of total clinical experience were excluded. These criteria were established to ensure that participants could reliably report perceptions of and attitudes toward AI in the current clinical environment.

The sample size was calculated using G*Power 3.1.9.7 based on the primary analysis of hierarchical multiple regression. Assuming a significance level of .05, power of .80, a medium effect size ($f^2=0.15$), and up to 10 predictors, the minimum required sample size was 118. In this calculation, predictors were defined as conceptually distinct variables at the design stage, and categorical variables were treated as single predictors for the purpose of sample size estimation. To account for potential dropout and to ensure sufficient power for additional subgroup and comparative analyses, 220 participants were recruited. After excluding two responses that did not meet the inclusion criteria, data from 218 participants were included in the final analysis.

3. Measurements

1) Demographic characteristics

General characteristics included gender, age, education level, graduate education experience, clinical department, job position, and years of clinical experience.

2) AI readiness

AI readiness was measured using the Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS), developed by Karaca et al. [25], which was translated with permission from the original authors and underwent content validity assessment. MAIRS-MS-derived readiness constructs have also been examined among healthcare professionals in clinical settings [22], suggesting potential applicability beyond student populations. Content validity was evaluated by an expert panel consisting of one nursing faculty member and clinical nurses with more than 10 years of clinical experience who held at least a master's degree in nursing and had prior experience related to AI use or implementation in hospital settings. The translated version demonstrated good content validity, with a scale-level content validity index average of 0.94. The instrument consists of 22 items across four dimensions—cognition, ability, vision, and ethics—rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), with higher scores indicating greater readiness to use AI in healthcare. Cronbach's α was .87 in the original study and .94 in this study.

3) Attitudes toward AI

Attitudes toward AI were measured using the Korean version of the General Attitudes toward Artificial Intelligence Scale (GAAIS-K) [13], translated from the original GAAIS [30]. GAAIS-K consists of 18 items, including 11 positive items and 7 negative items, rated on a 5-point Likert scale. Negative items were reverse-coded according to the scoring guidelines so that higher scores indicated more favorable attitudes on both subscales. For analysis, attitudes toward AI were treated as a single composite score derived from all 18 items, and positive and negative subscale scores were also calculated separately. This composite score was used to capture the overall tendency of attitudes toward AI across items. Cronbach's α was .88 for the positive subscale and .83 for the negative subscale in the original scale, .86 and .74 in GAAIS-K, and .83 and .78 in this study.

4) Behavioral intention to use AI

Behavioral intention to use AI was measured using three items [31] adapted for the healthcare context based on the UTAUT [29]. Items were rated on a 5-point Likert scale, with higher scores indicating stronger behavioral intention to use AI. Cronbach's α was .90 in the original scale, .69 in the adapted version, .72 in a previous study [32], and .71 in this study.

5) Open-ended survey items

In addition to the standardized instruments, participants were asked whether they had experience using AI-based programs or systems in clinical practice. Open-ended questions were included to explore clinical AI experiences and expectations, including experiences with AI use in clinical settings and nursing tasks for which AI was expected to be useful. Responses were grouped into categories based on similarity of meaning, and frequencies were calculated.

4. Data Collection

Data were collected from November 18 to December 11, 2024. Participants were recruited through convenience sampling using a recruitment notice posted on the hospital intranet bulletin board, which was accessible to all nurses employed at the study institution. Nurses who met the inclusion criteria and voluntarily agreed to participate completed the online survey.

The inclusion criteria were as follows: (1) registered nurses currently working at a tertiary hospital in South Korea, (2) nurses who had provided direct patient care in clinical settings for at least 1 year, and (3) individuals who understood the study purpose and provided informed consent. The exclusion criteria were as follows: (1) nurses not currently engaged in direct clinical practice, (2) nurses with less than 1 year of clinical experience, and (3) incomplete survey responses or withdrawal of consent. Participants received detailed information about the study purpose and procedures, provided electronic informed consent, and completed a structured self-report online questionnaire. The survey required approximately 10 minutes to complete. Measurement instruments were used after permission had been obtained from the original authors and translators.

5. Ethical Considerations

This study was approved by the Institutional Review Board of Seoul National University Hospital (No. H-2410-122-1579). All participants were informed of the study purpose and procedures and voluntarily agreed to participate through an online consent process.

6. Data Analysis

Data were analyzed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA) and R version 4.4.0 (R Foundation for Statistical Computing, Vienna, Austria). To examine the structural validity of the MAIRS-MS, confirmatory factor analysis was conducted using robust maximum likelihood estimation to account for potential non-normality. Differences in the major variables according to general characteristics were analyzed using an independent t-test and one-way analysis of variance. When the assumption of homogeneity of variance was violated, Welch's test was applied. Pearson correlation coefficients were calculated to examine relationships among the key variables.

Hierarchical regression diagnostic checks were performed to assess residual independence (Durbin-Watson test), multicollinearity (variance inflation factor [VIF]), linearity, and homoscedasticity. Hierarchical linear regression analysis was conducted using the mean score of the three behavioral intention to use AI items as the dependent variable. General characteristics, AI readiness, and attitudes toward AI were entered sequentially as predictors. Categorical variables were dummy-coded (0 = reference group, 1 = comparison group), with the most frequent category used as the reference group. Based on TAM and UTAUT, which conceptualize attitudes as a proximal determinant of behavioral intention, demographic variables were entered as control variables in the first block, followed by AI readiness as a more distal factor and attitudes toward AI in the final block [28,29]. Open-ended responses were summarized descriptively by reporting categories and frequencies to provide contextual information. Responses were grouped into categories based on similarity of meaning. Categorization was refined through repeated review and discussion between the researcher and a nursing faculty member until consensus was reached. These data were used to complement the quantitative findings and were not subjected to in-depth qualitative analysis.

RESULTS

1. General Characteristics of the Participants

A total of 218 nurses participated in the study, and most were women (n = 207, 95.0%). The largest age group was nurses in their 30s (n = 85, 39.0%), followed by those in their 20s (n = 77, 35.3%) and those aged 40 years or older (n = 56, 25.7%); the mean age was 34.35 years (standard deviation [SD], 7.31 years). Most participants held a bachelor's degree (82.1%), whereas 17.9% held a master's degree or higher. Among the participants, 31.2% had graduate-level education experience.

The largest proportion of participants worked in wards (52.3%), followed by intensive care units (20.6%), outpatient clinics (11.5%), emergency rooms (4.6%), operating rooms (4.6%), and other departments (6.4%). Most participants were staff nurses (96.8%), whereas 3.2% were head nurses. The mean duration of clinical experience was 10.99 years (SD, 7.43 years), and 52.3% had less than 10 years of experience. Nurses with AI experience accounted for 10.1% of the sample (Table 1).

2. AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI

The mean AI readiness score was 67.56 (SD, 12.97), and

Table 1. General Characteristics of Participants and Differences in AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI (N=218)

Characteristics	Categories	n (%)	M±SD	AI readiness		Attitudes toward AI		Behavioral intention to use AI	
				M±SD	t or F (p)	M±SD	t or F (p)	M±SD	t or F (p)
Sociodemographic characteristics									
Gender	Women	207 (95.0)	-	67.26±12.74	−1.18 (.265)	65.91±7.43	−1.76 (.107)	11.93±1.98	0.32 (.751)
	Men	11 (5.0)		73.18±16.44		70.73±8.92		11.82±1.08	
Age	20s	77 (35.3)	34.35±7.31	68.74±11.20	0.50 (.605)	65.66±6.78	0.68 (.506)	11.90±1.90	1.13 (.325)
	30s	85 (39.0)		67.06±12.54		66.91±8.07		12.14±2.00	
	≥40	56 (25.7)		66.70±15.72		65.70±7.83		11.64±1.89	
Education	Bachelor's	179 (82.1)	-	66.58±12.83	3.84 (.023)	65.60±6.99	5.89 (.003)	11.84±1.85	1.55 (.215)
	Master's	37 (17.0)		71.41±12.78		69.38±9.24		12.41±2.33	
	Doctoral	2 (0.9)		84.00±7.07		56.00±1.41		11.00±1.41	
Graduate education experience	Yes	68 (31.2)	-	72.09±11.99	3.67 (<.001)	68.46±8.40	2.87 (.005)	12.35±2.09	2.10 (.037)
	No	150 (68.8)		65.51±12.91		65.11±6.94		11.73±1.85	
Job-related characteristics									
Department	Wards	114 (52.3)	-	66.71±14.35	0.93 (.395)	65.30±7.70	1.82 (.164)	11.85±1.91	0.48 (.621)
	ICUs	45 (20.6)		67.16±11.12		66.47±7.42		12.18±2.01	
	Others	59 (27.1)		69.51±11.34		67.58±7.31		11.88±1.97	
Job position	Staff nurse	211 (96.8)	-	67.74±12.84	0.91 (.395)	66.13±7.60	−0.27 (.796)	11.91±1.94	−0.44 (.676)
	Head nurse	7 (3.2)		62.00±16.47		66.86±6.99		12.29±2.21	
Years of clinical experience	<10	114 (52.3)	10.99±7.43	68.96±11.60	1.97 (.142)	66.45±7.09	0.30 (.738)	12.00±1.97	1.24 (.291)
	10–19	73 (33.5)		65.15±14.72		66.08±8.09		12.03±1.89	
	≥20	31 (14.2)		68.06±12.97		65.26±8.12		11.42±1.95	
AI-related characteristics									
AI experience	Yes	22 (10.1)	-	68.41±16.50	−0.26 (.797)	67.14±9.32	−0.53 (.601)	12.05±2.13	−0.28 (.783)
	No	196 (89.9)		67.46±12.56		66.05±7.36		11.91±1.92	

AI = artificial intelligence; ICU = intensive care unit; M = mean; SD = standard deviation.

subscale scores for cognition, ability, vision, and ethics are presented in Table 2. The mean scores for attitudes toward AI and behavioral intention to use AI were 66.16 (SD, 7.57) and 11.93 (SD, 1.94), respectively.

To examine the structural validity of the MAIRS-MS in this sample, confirmatory factor analysis was additionally conducted. The analysis generally supported the original four-factor structure, with fit indices in a marginal but acceptable range (χ^2/df=2.54, comparative fit index=.898, Tucker-Lewis index=.884, root mean square error of approximation=.084, and standardized root mean square residual=.067). All standardized factor loadings were statistically significant and ranged from 0.53 to 0.91 across dimensions. Composite reliability values for the four factors ranged from 0.86 to 0.92, exceeding the threshold of .70. Average variance extracted values ranged from 0.49 to 0.68, which were at or near the recommended threshold of .50, supporting convergent validity.

Table 2. Descriptive Statistics for AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI (*N*=218)

Variables	No. of items	Range	M±SD
AI readiness	22	24–109	67.56±12.97
Cognition	8	9–39	21.50±5.19
Ability	8	8–40	26.09±5.66
Vision	3	3–15	9.15±2.41
Ethics	3	3–15	10.82±2.16
Attitudes toward AI	18	39–86	66.16±7.57
Positive	11	26–55	43.72±4.99
Negative	7	11–35	22.44±3.87
Behavioral intention to use AI	3	6–15	11.93±1.94

AI=artificial intelligence; M=mean; SD=standard deviation.

3. Differences in Participants' AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI according to General Characteristics

Differences in AI readiness, attitudes toward AI, and behavioral intention to use AI according to general characteristics are presented in Table 1. Significant differences according to education level were observed for both AI readiness (F=3.84, *p*=.023) and attitudes toward AI (F=5.89, *p*=.003). Nurses with graduate education experience had significantly higher scores for AI readiness (t=3.67, *p*<.001), attitudes toward AI (t=2.87, *p*=.005), and behavioral intention to use AI (t=2.10, *p*=.037).

4. Correlations among AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI

Correlations among the major variables are presented in Table 3. AI readiness was significantly and positively correlated with behavioral intention to use AI (r=.31, *p*<.001). The strongest correlation with behavioral intention was observed for attitudes toward AI (r=.64, *p*<.001). AI readiness was also significantly and positively correlated with attitudes toward AI (r=.30, *p*<.001).

At the subscale level, among the AI readiness dimensions, ability showed the strongest correlation with behavioral intention (r=.36, *p*<.001), followed by ethics (r=.30, *p*<.001), vision (r=.19, *p*<.01), and cognition (r=.18, *p*<.01). For attitudes toward AI, the positive attitude subscale (r=.66, *p*<.001) exhibited a stronger positive correlation with behavioral intention than the negative attitude subscale (r=.40, *p*<.001). This positive correlation reflects the reverse coding of the negative attitude items, such that higher scores indicate more favorable attitudes toward AI.

Table 3. Correlations among AI Readiness, Attitudes toward AI, and Behavioral Intention to Use AI (*N*=218)

Variables	AI readiness	Attitudes toward AI	Behavioral intention to use AI
		r (*p*)	
AI readiness	1	.30 (<.001)	.31 (<.001)
Cognition		.19 (.004)	.18 (.009)
Ability		.35 (<.001)	.36 (<.001)
Vision		.12 (.090)	.19 (.005)
Ethics		.27 (<.001)	.30 (<.001)
Attitudes toward AI		1	.64 (<.001)
Positive			.66 (<.001)
Negative			.40 (<.001)
Behavioral intention to use AI			1

AI=artificial intelligence.

5. Predictors of Behavioral Intention to Use AI

Hierarchical regression analysis was conducted to identify factors associated with behavioral intention to use AI (Table 4). This analytic approach was theoretically grounded in the TAM and the UTAUT [28,29]. By entering readiness variables first and attitudes subsequently, the analysis examined whether attitudes provided incremental explanatory power for behavioral intention, consistent with the conceptual pathway suggested in previous literature. This analytic strategy was intended to assess the sequential contributions of readiness and attitudes after controlling for general characteristics, rather than to formally test mediation effects.

In model 1, general characteristics were entered as control variables, and the explanatory power of the model was low (adjusted $R^2=.01$). Categorical variables were dummy-coded, with the most frequent category used as the reference group. None of the general characteristics, including age, showed a significant association with behavioral intention in this model. When AI readiness was added in model 2, the explanatory power increased significantly (adjusted $R^2=.09$, $\Delta R^2=.08$, $p<.001$), indicating that readiness contributed additional explanatory value beyond general characteristics. In model 3, attitudes toward AI were additionally entered, resulting in the highest explanatory power (adjusted $R^2=.43$, $\Delta R^2=.32$, $p<.001$). Attitudes toward AI emerged as a factor strongly associated with behavioral intention to use AI ($\beta=.61$, $p<.001$). Although the effect of AI readiness was attenuated after the inclusion of attitudes, it remained statistically significant ($B=0.17$, $\beta=.16$, $p=.005$). Gender was not significant in models 1 and 2 but emerged as a significant predictor in the final model.

Regression diagnostics indicated no violation of model assumptions. The Durbin-Watson statistic was 2.03, and VIF values ranged from 1.05 to 7.44. Although the VIF values for age (7.44) and the clinical experience group of 20 years or more (7.10) were higher than those of the other predictors, all VIF values remained below the commonly accepted threshold of 10, suggesting that severe multicollinearity was unlikely. Despite the elevated VIF values for these two predictors, they were retained for theoretical reasons, and the coefficient estimates remained stable. Residual diagnostics confirmed that the assumptions of normality (Shapiro-Wilk $p=.54$) and homoscedasticity (Breusch-Pagan $p=.59$) were satisfied. The maximum Cook's distance was 0.18, indicating that no influential observations substantially affected model stability.

Table 4. Hierarchical Regression Analysis Predicting Behavioral Intention to Use AI ($N=218$)

Variables	Step 1				Step 2				Step 3			
	B	SE	β	*p*	B	SE	β	*p*	B	SE	β	*p*
General characteristics												
Gender	–0.13	0.20	–.04	.519	–0.21	0.20	–.07	.279	–0.38	0.16	–.13	.017
Age	–0.01	0.02	–.17	.364	–0.01	0.02	–.09	.630	–0.00	0.01	–.04	.755
Graduate education experience	0.26	0.10	.19	.009	0.15	0.10	.10	.147	0.01	0.08	.01	.901
Department												
ICUs	0.08	0.12	.05	.489	0.09	0.11	.06	.399	0.05	0.09	.03	.543
Others	0.07	0.11	.05	.533	0.02	0.10	.01	.847	–0.10	0.08	–.07	.221
Job position	0.08	0.26	.02	.771	0.20	0.25	.05	.432	0.16	0.20	.04	.436
Years of clinical experience												
10–19	0.12	0.17	.08	.508	0.12	0.17	.09	.458	0.12	0.13	.08	.389
≥20	–0.03	0.33	–.02	.923	–0.10	0.32	–.05	.760	–0.02	0.25	–.01	.927
AI experience	0.05	0.15	.02	.760	0.03	0.14	.01	.831	–0.02	0.11	–.01	.864
AI readiness					0.33	0.07	.31	<.001	0.17	0.06	.16	.005
Attitudes toward AI									0.94	0.09	.61	<.001
Model fit	Adj.$R^2=.01$				Adj.$R^2=.09$; $\Delta R^2=.08$				Adj.$R^2=.43$; $\Delta R^2=.32$			

Dummy variables: gender (women=reference); graduate education experience (no=reference); department (wards=reference); job position (staff nurse=reference); Years of clinical experience (<10 years=reference); AI experience (no=reference). Durbin-Watson=2.03; VIF range=1.05–7.44.

Adj.R^2=adjusted coefficient of determination; AI=artificial intelligence; β=standardized coefficient; ICU=intensive care unit; SE=standard error; VIF=variance inflation factor.

6. Expected Areas of AI Use in Clinical Nursing Practice

Table 5 presents the descriptive results of the open-ended survey questions regarding nurses' experiences with AI and their expectations for AI applications in clinical nursing practice. Nurses identified potential AI applications in both direct patient care and indirect nursing activities.

In addition to the quantitative findings, open-ended responses indicated that nurses emphasized the need for adequate education, institutional support, and safeguards to ensure patient safety during AI implementation, while some also expressed positive expectations regarding improved work efficiency.

DISCUSSION

This study has both academic and practical significance as one of the few studies to examine the relationships among AI readiness, attitudes toward AI, and behavioral intention to use AI among clinical nurses in a tertiary hospital. Previous studies primarily targeted nursing students [13-15], and some focused on primary healthcare workers [26], thereby reflecting educational expectations or community healthcare contexts. Studies involving clinical nurses have recently emerged; however, most have reported only levels of awareness and attitudes [19], whereas one study involving intensive care unit nurses examined AI readiness and acceptance but was limited to a specific unit [20]. In contrast, the present study is distinguished by its comprehensive assessment of AI readiness, attitudes toward AI, and behavioral intention to use AI among nurses working across diverse departments in a tertiary hospital.

In this study, clinical nurses demonstrated an above-midpoint level of AI readiness, indicating a generally favorable level of perceived readiness for AI-related practice. This level of readiness should be interpreted in light of the characteristics of the measurement instrument, which conceptualizes AI readiness as a multidimensional construct en-

Table 5. Descriptive Results of Open-Ended Survey Questions on AI Use in Nursing Practice

Categories	n (%)	Example quotes
AI usage experiences in clinical settings (n = 21)[†]		
Patient risk/prognosis prediction	7 (33.3)	"Patient risk analysis," "Deterioration prediction"
Work support	6 (28.6)	"Diagnostic prediction," "Triage assistance"
Imaging interpretation support	5 (23.8)	"Chest X-ray AI reading," "Automated measurement of lung fields"
Communication/information retrieval	3 (14.3)	"English translation and clinical knowledge lookup," "Evidence summarization"
Nursing tasks in which AI is expected to be useful (n = 218)		
Patient monitoring/prediction	61 (28.0)	"Prediction of falls and pressure ulcers," "Early detection of patient deterioration"
Test result/imaging analysis	49 (22.5)	"Interpretation of test results," "Assistance with imaging tests"
Staffing/work allocation	37 (17.0)	"Efficient allocation of nursing staff," "Reallocation according to patient condition"
Medication/administration	28 (12.8)	"Drug interaction check," "Adjustment of medication timing"
Nursing records/documentation	21 (9.6)	"Automated nursing records," "Auto-entry in charts"
Unknown/no response	18 (8.3)	"Not sure yet," "Nothing comes to mind"
Others	4 (1.8)	"Support for medical decision-making," "Searching medical records," "Health consultation chatbot"

AI = artificial intelligence; [†]This item was answered only by participants with AI experience. One participant did not provide a response.

https://doi.org/10.7475/kjan.2026.0101

compassing perceived ability, ethical considerations, vision, and acceptance of AI, rather than as direct evidence of extensive hands-on experience. Accordingly, the observed readiness reflects nurses' evaluative and perceptual preparedness toward AI within the clinical context. Consistent with the relatively higher scores observed in the ethics dimension, the open-ended responses revealed positive expectations regarding improved work efficiency and clinical support for patient monitoring and risk prediction, all of which are closely related to patient safety in clinical care. These findings suggest that nurses' AI readiness reflects contextual and perception-based preparedness that coexists with careful consideration of clinical responsibility and safety, in line with the Code of Ethics for Nurses [33].

A previous study using the same instrument reported higher AI readiness among physicians than among nurses [22]. This difference may partly reflect greater opportunities for physicians to engage directly with AI systems in diagnostic and decision-making processes. In contrast, AI-related nursing research has more often focused on attitudes and adaptation rather than readiness itself [13-21]. Given potential differences in professional roles and practice environments, it is important to consider whether the MAIRS-MS adequately captures AI readiness in clinical nurses before interpreting these comparisons.

Although the MAIRS-MS was originally developed for medical students, the present findings indicate that its four-factor structure was generally retained in a clinical nursing population. The overall model fit indices were slightly below conventional thresholds, which may reflect contextual differences between student and practicing clinician populations. Nevertheless, the factor loadings and convergent validity indicators supported the structural adequacy of the instrument. These findings are consistent with recent studies applying MAIRS-related constructs to healthcare professionals beyond student samples [22]. Together, these results suggest that the MAIRS-MS may be cautiously applied to clinical nurses, although further validation in diverse professional samples is warranted.

Among the AI readiness dimensions, ability and ethics showed relatively stronger associations with behavioral intention than vision in the correlation analysis. This finding suggests that clinical nurses place greater importance on the practical feasibility of AI use and responsibility for patient safety than on future-oriented expectations. The vision dimension showed a relatively weaker association than the other dimensions, indicating that long-term or abstract perceptions of AI may not yet have translated into concrete intentions in clinical practice. This pattern contrasts with findings in medical students, for whom future-oriented perceptions played a more prominent role [25], and with findings in intensive care unit nurses, in whom perceived usefulness and facilitating conditions were emphasized [20]. Overall, these results suggest that AI acceptance among clinical nurses is grounded primarily in immediate applicability and ethical considerations rather than in visionary expectations, reflecting the realities of frontline nursing practice.

Graduate education experience was associated with higher AI readiness and more positive attitudes toward AI; however, it did not remain significant in the final regression model. This pattern is consistent with previous studies suggesting that educational exposure may influence behavioral intention indirectly through attitudes or perceived competence rather than as an independent determinant [14]. In this context, graduate education may contribute to behavioral intention by shaping nurses' cognitive and evaluative frameworks regarding AI, including conceptual understanding, critical appraisal skills, and ethical awareness. These educational influences are more likely to be reflected in attitudes toward AI, which are more proximally associated with behavioral intention. Although this pattern suggests a potential indirect pathway, it should be interpreted cautiously because formal mediation analysis was not conducted. These findings imply that formal education alone may be insufficient without corresponding changes in attitudes and readiness, highlighting the need for additional institutional and educational support to strengthen nurses' AI readiness in clinical settings.

Most demographic variables, such as age, department, and job position, were not significantly associated with behavioral intention. Notably, gender was not significant in Models 1 and 2 but emerged as a significant predictor in the final model after accounting for psychological factors such as attitudes. This finding suggests that the association between gender and behavioral intention to use AI may depend on the inclusion of psychological variables and should therefore be interpreted as an adjusted association within the full model rather than as a direct effect. Overall, these results are consistent with previous studies reporting inconsistent or negligible effects of demographic factors on AI acceptance, suggesting that individual perceptions and attitudes play a more central role than sociodemographic characteristics [16,17]. However, because male participants represented only a small proportion of the sample (n = 11, 5.0%), this finding should be interpreted cautiously, as the substantial gender imbalance may limit the stability and generalizability of this association.

In the hierarchical regression analysis, attitudes toward AI showed a strong association with behavioral intention to use AI in the final model ($\beta = .61$, $p < .001$). This finding is consistent with the TAM and the UTAUT, which conceptualize attitudes as a proximal factor associated with behavioral intention [28,29]. In line with this theoretical framework, previous empirical studies have also identified attitudes toward AI as an important factor associated with behavioral intention to use AI [13-16].

However, the emphasis placed on AI acceptance appears to vary across participant groups. Previous studies have shown that vision and innovation acceptance were more salient among medical students [25], whereas educational experience and the mediating role of attitudes were emphasized among nursing students [13,14]. Community nurses have also highlighted the perceived impact of AI on professional practice [26]. In contrast, the present findings showed that the ability and ethics dimensions were more strongly associated with behavioral intention than the vision dimension among nurses in a tertiary hospital. This pattern suggests that AI acceptance in this group may be more closely related to immediate applicability and patient safety considerations. However, because these dimensions were examined using correlation analyses and were not simultaneously included in the regression model, these findings should be interpreted as reflecting differences in association strength rather than differential causal influence. These results underscore the context-dependent nature of AI acceptance and highlight the clinical realities of frontline nursing practice.

This pragmatic orientation is further reflected in the specific areas of expected AI utilization identified in the open-ended responses. Nurses identified potential AI applications in both direct and indirect nursing activities. Specifically, the prevention of medication errors and support for patient monitoring correspond to direct nursing activities related to patient safety, whereas automated documentation and nurse staffing support represent indirect activities that enhance efficiency and administrative management. Previous literature has similarly emphasized clinical applications such as monitoring, documentation automation, and prediction of nursing outcomes [34], and exploratory studies have reported high perceived usefulness of AI for repetitive and time-consuming tasks [35]. The present findings are consistent with this evidence, indicating that nurses view AI as augmenting their work and enhancing patient safety rather than replacing nursing roles.

Overall, this study identified relationships among AI readiness, attitudes toward AI, and behavioral intention to use AI among clinical nurses and additionally explored expected areas of AI utilization in clinical nursing practice through open-ended responses. Unlike previous studies focusing on students or specific departments, this study provides empirical evidence from nurses directly involved in patient care across diverse clinical settings. These findings provide foundational data for developing strategies to strengthen nurses' AI competency through educational and institutional support.

This study has several limitations. First, the single-center, cross-sectional design limits the generalizability of the findings, and the results may not be directly applicable to nurses working in healthcare settings with less access to digital infrastructure. Because participation was voluntary and the survey was conducted online, nurses with greater interest in AI may have been more likely to respond, potentially leading to overestimation of AI readiness. However, only 10.1% of participants reported direct clinical experience with AI, suggesting that the sample largely consisted of nurses with limited direct exposure to AI in practice. In addition, perceptions of AI are evolving rapidly; therefore, these findings reflect a specific time point and may change over time. Further research should adopt longitudinal and multicenter designs.

Although the sample size met conventional minimum criteria for confirmatory factor analysis, it may still be considered modest for achieving stable structural validation. Therefore, the confirmatory factor analysis findings should be interpreted cautiously, and further validation in larger and more diverse nursing populations is warranted. In addition, the effect of AI readiness on behavioral intention was attenuated after attitudes toward AI were entered into the hierarchical regression model, suggesting a potential indirect role of attitudes. However, formal mediation analysis was not conducted. Accordingly, this finding should be interpreted cautiously and regarded as exploratory. Future studies may further examine this potential mechanism using mediation or path-analytic approaches, such as structural equation modeling.

Finally, the analysis of the open-ended responses was limited to basic categorization. Future studies using in-depth interviews or focus groups are warranted to provide a deeper understanding of nurses' perceptions of AI.

CONCLUSION

The findings of this study indicate that attitudes toward AI were strongly associated with behavioral intention to use AI among clinical nurses in a tertiary hospital. AI readiness and graduate education experience were related to attitudes toward AI, suggesting that these factors may contribute to behavioral intention indirectly rather than exerting a direct effect. In the correlation analyses, the ability and ethics dimensions of AI readiness tended to show stronger associations with behavioral intention in clinical contexts, suggesting that nurses' perceptions may be grounded primarily in practical needs and safety considerations. In the open-ended responses, nurses expressed expectations that AI could contribute to both direct and indirect nursing activities, particularly in relation to patient safety and work efficiency. Taken together, these findings suggest that educational and organizational strategies aligned with clinical nurses' practical needs and ethical considerations may facilitate the integration of AI into nursing practice, based on the associations observed in this study.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design acquisition - JES and YHP; analysis - JES; interpretation of the data - JES; and drafting or critical revision of the manuscript for important intellectual content - JES and YHP.

FUNDING

This work was supported by the 2024 Graduate Student Research Grant from the Research Institute of Nursing Science, Seoul National University.

ACKNOWLEDGEMENT

ChatGPT (OpenAI, San Francisco, CA, USA) was used to refine the clarity and fluency of the English expressions during manuscript preparation.

DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding author.

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ORIGINAL ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 182-192, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2025.1203

KJAN
Korean Journal of
Adult Nursing

Factors Influencing Quality of Life in Colorectal Cancer Patients with a Stoma during the First 6 Months after Surgery

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Received: December 3, 2025
Revised: March 9, 2026
Accepted: March 12, 2026

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Purpose: This study aimed to identify predictors of quality of life (QoL), including self-efficacy, social support, illness perceptions, and resilience, among colorectal cancer patients during the first 1 to 6 months after stoma surgery. **Methods:** A predictive correlational design was used with 142 adult patients who had undergone stoma surgery within the preceding 1 to 6 months. Data were collected using validated instruments measuring QoL, self-efficacy, social support, illness perceptions, and resilience. The data were analyzed using descriptive statistics, the independent t-test, one-way analysis of variance, the Games-Howell post-hoc test, Pearson correlation coefficients, and hierarchical multiple linear regression analysis. **Results:** The participants had a mean age of 56.15 years (standard deviation, 6.51 years); 67.6% were male, and 57.0% had a temporary stoma. In model 1, the method of paying medical expenses significantly predicted QoL, explaining 6.0% of the variance (adjusted $R^2 = .06$, $p = .006$), with self-financed patients reporting lower QoL than insured patients. In model 2, the addition of psychosocial variables (self-efficacy, social support, illness perceptions, and resilience) substantially improved the model, explaining 70.0% of the variance (adjusted $R^2 = .70$, $p < .001$). In the final model, illness perceptions ($\beta = -.61$), social support ($\beta = .32$), resilience ($\beta = .20$), and self-efficacy ($\beta = .19$) were significant predictors (all $p < .001$), whereas method of paying medical expenses was no longer significant. **Conclusion:** This study provides evidence to support the development of interventions targeting illness perceptions, social support, resilience, and self-efficacy to improve QoL among stoma patients during the early postoperative period.

Key Words: Illness behavior; Quality of life; Resilience; Self efficacy; Social support

INTRODUCTION

Colorectal cancer (CRC) remains a major global public health concern. According to recent global estimates, it is the third most commonly diagnosed cancer, with Asia accounting for nearly half of all newly diagnosed cases [1]. China has the highest incidence in the region, representing more than half of the CRC burden in Asia and approximately one-quarter of cases worldwide [2]. Because incidence rises markedly after 50 years of age, CRC poses an increasing healthcare challenge both globally and within China [3].

Surgery remains the cornerstone of CRC treatment, and many patients require a stoma, a surgically created opening that diverts feces, which may be temporary or permanent [4]. Although stoma formation can be lifesaving, it can also substantially affect patients' quality of life (QoL) by influencing their physical, psychological, social, and spiritual well-being.

The early postoperative period is particularly challenging for these patients. Previous studies have shown clinically meaningful declines in QoL after CRC surgery, especially during the first postoperative month [5]. The presence of a stoma further complicates recovery by disrupting everyday life and requiring patients to adapt to new self-care demands and altered social interactions [6]. Common physical problems include leakage, peristomal complications, pain, sleep disturbance, and gas incontinence [7]. Patients also frequently experience psychological difficulties, including anxiety about the future, interpersonal strain, sexual dysfunction, and restrictions in physical activity and diet [8].

Guided by individual and family self-management theory (IFSMT), this study conceptualized QoL as a distal outcome that emerges through the interaction of contextual, process, and proximal factors [9]. Within this framework, contextual factors such as illness perceptions and resilience shape how patients with CRC and a stoma understand their condition, adjust to bodily changes, and cope with the uncertainty of illness. Process factors, including self-efficacy and social support, serve as central self-management mechanisms that help patients engage in health-promoting behaviors, adhere to treatment, and manage stoma-related symptoms effectively. These processes, in turn, influence proximal outcomes such as functional status, emotional adjustment, and role participation, all of which are important indicators of patient well-being in oncology care. Ultimately, these interrelated pathways converge to affect QoL.

Self-efficacy refers to an individual's belief in their ability to organize and carry out the actions needed to manage health-related demands [10]. It influences cognition, motivation, and coping behavior and has been associated with better QoL in patients with a colostomy [11]. In contrast, lower self-efficacy has been associated with fatigue and more negative illness perceptions [12]. By strengthening a sense of control, self-efficacy may help reduce stoma-related anxiety and depression and facilitate psychological adjustment [13].

Social support, which includes assistance from family members, friends, and healthcare providers, is another important determinant of QoL. Support from healthcare professionals facilitates psychological adjustment, whereas family support plays a central role in self-care and emotional well-being [7]. Previous evidence suggests that strong social support is associated with better QoL in CRC patients with a stoma [14]. In addition, social support may indirectly strengthen self-efficacy, creating a reinforcing cycle that promotes self-management and adaptation.

Illness perceptions are also critical in shaping QoL outcomes. Patients' beliefs about the severity, consequences, and emotional impact of illness strongly influence psychological adjustment [12]. Among stoma patients, more negative illness perceptions have been associated with poorer psychological adaptation and lower QoL [15].

Resilience, defined as the capacity to adapt positively in the face of adversity, has increasingly been recognized as a protective factor among cancer patients. Individuals with greater resilience tend to show better psychological adjustment, lower stress, and higher QoL, even under similar disease conditions [16]. Thus, resilience may lessen the psychological burden associated with stoma care and support adaptive coping and longer-term well-being.

Although self-efficacy, social support, illness perceptions, and resilience are established correlates of QoL in CRC patients, most of the available evidence has been derived from Western populations. Cultural differences in lifestyle, social structure, and values may limit the generalizability of these findings to Asian populations. Given the increasing incidence of CRC in China [17], context-specific research is needed. Therefore, this study aimed to identify predictors of QoL among CRC patients with a stoma in Wenzhou, China, in order to inform culturally appropriate interventions and improve health outcomes.

METHODS

1. Study Design

This study employed a predictive correlational design to examine factors associated with QoL in CRC patients with a postoperative stoma. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

2. Participants and Setting

Participants were patients who had undergone stoma surgery for CRC at First Affiliated Hospital of Wenzhou Medical University. Recruitment was conducted in the outpatient clinic of the Department of Colorectal and Anal Surgery.

Eligible participants were adults aged 18 to 60 years who had undergone stoma surgery within the previous 1 to 6 months and were able to communicate in Mandarin or the Wenzhou dialect. The upper age limit of 60 years was determined on the basis of policy and clinical considerations. In China, individuals older than 60 years are officially classified as older adults according to national demographic and health policy standards [18]. This population generally has a greater burden of comorbid conditions, reduced functional reserve (i.e., a decline in intrinsic capacity), and age-related changes in the interaction between personal capacity and social environments that affect functional ability. These factors are established influences on QoL outcomes [19]. Restricting the sample to patients aged 60 years or younger was therefore intended to reduce age-related heterogeneity and allow a more focused examination of psychosocial predictors of QoL during the early postoperative adjustment period after stoma surgery.

Patients who were currently receiving chemotherapy or radiotherapy, those with metastatic disease, and those with a documented history of psychiatric disorders were excluded. The exclusion of patients undergoing active anticancer treatment was based on both clinical and methodological considerations. Clinically, chemotherapy and radiotherapy, as key components of multimodal cancer treatment, are associated with substantial adverse effects. Evidence from a randomized trial in rectal cancer has shown that such treatment can result in chronic toxicity, including neurotoxicity and diarrhea, as well as persistent functional deterioration such as stool incontinence, all of which can substantially impair health-related QoL [20]. Methodologically, including patients receiving active treatment would have introduced a major confounding factor, making it difficult to distinguish the effects of stoma-related challenges and psychosocial adaptation from the acute systemic burden of adjuvant therapy. Accordingly, this study focused on patients in the early postoperative recovery phase who were not concurrently exposed to the substantial physiological and psychological burdens of active anticancer treatment.

The required sample size was calculated using G*Power ver. 3.1.9.2 [17]. For multiple linear regression analysis, a medium effect size ($f^2=0.15$), a significance level of .05, a statistical power of .95 [18], and four predictor variables were specified, yielding a minimum required sample size of 129. After allowing for a 10% potential non-response rate, the target sample size was set at 142. A total of 142 questionnaires were distributed, and all were returned with complete data, resulting in a response rate of 100%.

3. Measurements

The instruments used in this study, including the Chinese-language versions, were employed with permission from the original authors. Participants' general characteristics included age, sex, marital status, education level, employment status, residence, household composition, monthly household income, the method of paying medical expenses, cancer stage, tumor location, postoperative period, surgical method, type of stoma, and postoperative complications.

1) City of Hope Quality of Life-Ostomy Questionnaire

The City of Hope Quality of Life-Ostomy Questionnaire was originally developed by Grant and Davis [21] to assess QoL across four domains: physical, psychological, social, and spiritual. The Chinese version, translated and validated by Gao et al. [22], consists of 32 items rated on an 11-point Likert scale ranging from 0 to 10. Each item is scored from 0 to 10, with higher total scores indicating better QoL. Negatively worded items were reverse-coded before analysis. The overall QoL score calculated as the mean of all items. Cronbach's α for the scale was .95 in the study of Gao et al. [22] and .93 in the present study.

2) General Self-Efficacy Scale

The General Self-Efficacy Scale was originally developed by Schwarzer and Jerusalem [23]. The Chinese version, translated and adapted by Zhang and Schwarzer [24], retains the original structure and has shown good reliability. The scale consists of 10 items rated on a 4-point Likert scale ranging from "not at all true" (1 point) to "exactly true" (4 points). Total scores range from 10 to 40, with higher scores indicating greater self-efficacy. Cronbach's α for the scale was .91 in the original study [24] and .79 in the present study.

3) Perceived Social Support Scale

The Perceived Social Support Scale was developed by Zimet et al. [25] and translated into Chinese by Jiang. It consists of 12 items measuring support from three sources: family, friends, and significant others. Each item is rated on a 7-point Likert scale ranging from “strongly disagree” (1 point) to “strongly agree” (7 points). Total scores range from 12 to 84. For descriptive purposes and to facilitate clinical interpretation, total scores were categorized as low (12–36), moderate (37–60), or high (61–84), based on categorizations used in prior studies involving Chinese patient populations [26]. Higher scores indicate greater perceived social support. Cronbach’s α for the scale was .84 in the study of Zhang et al. [26] and .87 in the present study.

4) Brief Illness Perception Questionnaire

The Brief Illness Perception Questionnaire was developed by Broadbent et al. [27] to assess cognitive and emotional representations of illness. The Chinese version, validated by Mei et al. [28], consists of nine items. Items 1 to 8 are rated on a scale from 0 to 10, with higher scores indicating more negative perceptions; among these, items 3, 4, and 7 are reverse-coded. Item 9 is an open-ended question asking patients to list the perceived causes of their illness. Total scores range from 0 to 80, with higher scores reflecting more negative illness perceptions overall. Cronbach’s α for the scale was .77 in the study of Mei et al. [28] and .80 in the present study.

5) Connor-Davidson Resilience Scale

The Connor-Davidson Resilience Scale was developed by Connor and Davidson [29] and adapted into Chinese by Yu and Zhang [30] through forward-backward translation. The scale contains 25 items across three domains: tenacity (13 items), strength (8 items), and optimism (4 items). Each item is rated on a 5-point Likert scale ranging from “not true at all” (0 points) to “true nearly all the time” (4 points). Total scores range from 0 to 100, with higher scores indicating greater resilience. Cronbach’s α for the scale was .91 in Yu and Zhang’s study [30] and .89 in the present study.

4. Data Collection

Data were collected between April and September 2024 in the outpatient departments of the First Affiliated Hospital of Wenzhou Medical University, China. Before the study began, ethical approval was obtained from Burapha University and the hospital’s Institutional Review Board.

Each day, a complete list of patients attending the colorectal and anal surgery outpatient clinic was generated from the hospital’s electronic medical record system. This list served as the sampling frame. Trained clinical staff screened patients against the predefined inclusion and exclusion criteria, and all eligible patients were approached and informed about the study. Those who expressed an initial willingness to participate were included on the daily eligibility list.

Simple random sampling was then applied to the list of eligible patients. Specifically, each eligible patient was assigned a unique numerical identification code. A computerized random number generator, specifically the Microsoft Excel RAND function, was used by the researcher to select approximately 50% of eligible patients each day for study enrollment. This procedure ensured that each eligible patient had an equal and known probability of selection, thereby supporting probability-based sampling and population inference.

The researcher then contacted the randomly selected patients in person in the outpatient clinic, provided a detailed explanation of the study, obtained written informed consent, and administered the self-report questionnaires. Recruitment was conducted consecutively using the same procedure until the predetermined sample size of 142 participants was reached.

5. Ethical Considerations

The study protocol was approved by the Institutional Review Board (IRB) of Burapha University in Thailand (No. G-HS117/2566) and the First Affiliated Hospital of Wenzhou Medical University in China (No. KY2024-003). All participants were fully informed about the study’s purpose, procedures, potential risks and benefits, and their right to withdraw at any time without penalty. Written informed consent was obtained from each participant before data collection. All consent forms were submitted to the IRBs upon completion of the study. The collected data were anonymized, assigned unique identification codes, and stored in encrypted electronic files. All data will be securely retained for three years after study completion and then permanently deleted.

6. Data Analysis

Data were analyzed using IBM SPSS ver. 27.0.1 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics and study variables. Differences in QoL according to categorical variables were examined using the independent t-test or one-way analysis of variance (ANOVA) with the Games-Howell post-hoc test, as appropriate. Pearson correlation coefficients were calculated to assess bivariate associations among continuous variables.

Before the predictor analysis, all assumptions for multiple regression were examined. Normality of the residuals was supported by the Shapiro-Wilk test (p = .932) and visual inspection of the Q-Q plot, which showed close alignment with the 45° reference line. Homoscedasticity was confirmed using the Breusch-Pagan test (p = .566), and residual scatterplots indicated a random and uniform distribution. The Durbin-Watson statistic (1.61) suggested independence of residuals. In addition, variance inflation factor values ranged from 1.00 to 1.08, indicating no evidence of multicollinearity.

Hierarchical multiple regression analysis was conducted to examine factors associated with QoL among CRC patients with a stoma. Variables that showed significant associations with QoL in univariate analyses (p < .05) were considered potential covariates and entered in the first block of the model to control for their effects. Categorical variables were dummy-coded before analysis, with appropriate reference categories specified.

RESULTS

1. Participant General Characteristics

Most participants (88.8%) were 51 to 60 years of age, with a mean age of 56.15 years (standard deviation [SD] = 6.51). The majority were male (67.6%), married (93.0%), had completed primary education (62.8%), and were unemployed (45.7%). The most common monthly household income category was 2,000 to 3,999 Renminbi (31.6%). In terms of clinical characteristics, 55.7% had stage III CRC, and 73.9% had rectal cancer. Most participants (64.1%) were within 1 to 2 months after surgery, and 57.0% had a temporary stoma. Postoperative complications were reported by 6.3% of the participants.

Differences in QoL according to general characteristics were statistically significant only for the method of paying medical expenses (F = 5.40, p = .006). Post-hoc comparisons using the Games-Howell test showed that participants who self-financed their medical expenses reported significantly lower QoL scores than those covered by medical insurance (p < .05) or rural insurance (p < .05). No significant difference was observed between the medical insurance and rural insurance groups (Table 1).

Table 1. Univariate Analysis of Quality of Life (N = 142)

Variables	Categories	n (%) or M ± SD	Quality of life	t or F (p)
			M ± SD	
Age (year)	31–40	9 (6.3)	4.29 ± 1.86	0.92 (.400)
	41–50	7 (4.9)	3.20 ± 1.55	
	51–60	126 (88.8)	3.87 ± 1.58	
		56.15 ± 6.51		
Sex	Male	96 (67.6)	3.86 ± 1.56	–0.04 (.965)
	Female	46 (32.4)	3.87 ± 1.69	
Marital status	Married	132 (93.0)	3.84 ± 1.59	–0.50 (.615)
	Others[†]	10 (7.0)	4.11 ± 1.79	
Education level	Illiteracy	7 (4.9)	4.79 ± 1.51	1.99 (.099)
	Primary school	89 (62.8)	3.96 ± 1.63	
	Secondary school	32 (22.5)	3.27 ± 1.45	
	High school	9 (6.3)	3.93 ± 1.56	
	Diploma or higher	5 (3.5)	4.46 ± 1.48	
Employment status	Unemployed	65 (45.7)	4.02 ± 1.61	0.90 (.464)
	Retirement	39 (27.5)	3.63 ± 1.54	
	Self-employed	22 (15.5)	3.74 ± 1.61	
	Farmer	14 (9.9)	3.75 ± 1.76	
	Officer	2 (1.4)	5.45 ± 0.77	
Residence	In Wenzhou	131 (92.3)	3.88 ± 1.60	0.46 (.648)
	Not in Wenzhou	11 (7.7)	3.65 ± 1.63	
Household composition	Husband or wife	126 (88.8)	3.84 ± 1.60	0.21 (.810)
	Sons and daughters	11 (7.7)	3.83 ± 1.68	
	Others[‡]	5 (3.5)	4.32 ± 1.76	
Monthly household income in RMB (7 RMB = 1 USD)	Less than 2,000	12 (8.5)	4.41 ± 1.65	0.75 (.585)
	2,000 to 3,999	45 (31.6)	3.94 ± 1.55	
	4,000 to 5,999	42 (29.5)	3.64 ± 1.51	
	6,000 to 7,999	16 (11.3)	3.65 ± 1.75	
	8,000 to 9,999	14 (9.9)	3.62 ± 1.88	
	More than 10,000	13 (9.2)	4.28 ± 1.55	
Method of paying medical expenses[§]	Medical insurance[a]	61 (43.0)	3.70 ± 1.59	5.40 (.006) (a > c, b > c)
	Rural insurance[b]	76 (53.5)	4.12 ± 1.56	
	Self-financed[c]	5 (3.5)	1.90 ± 0.46	
Cancer stage	Stage I	31 (21.8)	3.71 ± 1.61	0.65 (.524)
	Stage II	32 (22.5)	3.67 ± 1.74	
	Stage III	79 (55.7)	4.00 ± 1.54	

(Continued on the next page)

Table 1. Continued

Variables	Categories	n (%) or M±SD	Quality of life M±SD	t or F (p)
Location of tumor	Colon	37 (26.1)	3.81±1.62	−0.23 (.819)
	Rectum	105 (73.9)	3.88±1.60	
Postoperative date (month)‖	1 to <2	91 (64.1)	3.82±1.61	0.21 (.933)
	≥2 to <3	16 (11.3)	4.02±1.60	
	≥3 to <4	9 (6.3)	4.10±1.75	
	≥4 to <5	9 (6.3)	3.53±1.49	
	≥5 to <6	17 (12.0)	3.96±1.64	
Surgical method	Colostomy	69 (48.6)	4.04±1.65	1.29 (.279)
	Ileostomy	70 (49.3)	3.72±1.54	
	Small bowel stoma	3 (2.1)	2.86±1.51	
Type of stoma	Temporary stoma	81 (57.0)	3.70±1.56	−1.41 (.160)
	Permanent stoma	61 (43.0)	4.08±1.64	
Postoperative complications	No	133 (93.7)	3.82±1.60	−1.07 (.285)
	Yes	9 (6.3)	4.41±1.48	

M=mean; RMB=Renminbi; SD=standard deviation; †Others included single, divorce and bereavement; ‡Others included living alone and residing in a nursing home; §Games-Howell post-hoc test; ‖Patients were categorized into mutually exclusive time intervals based on the time from surgery to follow-up: 1 to <2 months, 2 to <3 months, 3 to <4 months, 4 to <5 months, and 5 to <6 months.

2. Descriptive Statistics of the Variables

As shown in Table 2, the overall QoL score was 3.86 (SD=1.60) on a scale ranging from 0 to 10. This mean score was substantially below the midpoint of the scale (5.00), suggesting a generally low level of perceived QoL among the participants. This interpretation is further supported by the sub-dimension scores, as physical, social, and spiritual well-being all averaged below 4.0. Although the psychological well-being subscale score (5.14) was closer to the midpoint, it remained only modest. The developers of the Chinese version noted that a mean item score above 5 generally indicates at least moderate QoL [22]. In the present sample, the overall mean item score (3.86) and most of the sub-dimension scores were below this threshold, collectively indicating compromised QoL during the early postoperative period.

Table 2. QoL Levels among the Participants ($N=142$)

Variables	M±SD (range)
Overall QoL	3.86±1.60 (0–6.0)
Physical well-being	3.91±2.05 (0–8.2)
Social well-being	2.44±1.87 (0–6.3)
Psychological well-being	5.14±1.63 (0–8.0)
Spiritual well-being	3.43±1.52 (0–6.8)

M=mean; QoL=quality of life; SD=standard deviation.

3. Correlations among Main Variables

Pearson correlation analysis was performed to examine the relationships among QoL, self-efficacy, social support, illness perceptions, and resilience. In addition, to assess the association between the categorical variable method of paying medical expenses and the continuous study variables, eta (η) coefficients were calculated from one-way ANOVA. As shown in Table 3, self-efficacy ($r=.38$, $p<.001$) and social support ($r=.43$, $p<.001$) were significantly and positively correlated with QoL at a moderate level. Resilience also showed a weak positive correlation with QoL ($r=.20$, $p<.05$). In contrast, illness perceptions were significantly and negatively correlated with QoL at a high level ($r=-.70$, $p<.001$). Furthermore, the method of paying medical expenses was significantly associated with QoL ($\eta=.27$, $p<.01$), indicating that patients with different payment methods had different QoL scores.

4. Factors Influencing Quality of Life in Patients with a Stoma after Surgery

Hierarchical multiple linear regression analysis was conducted to identify factors associated with QoL among CRC patients with a stoma (n=142). The results are summarized in Table 4. Variables that showed significant associations with QoL in univariate analyses ($p<.05$) were considered candidate covariates. Among these, the method of paying medical expenses was identified as the only demographic variable meeting the inclusion criterion and was therefore entered as a control variable in the first block of the model after dummy-coding (reference category: medical insurance). Clinical variables such as type of stoma and surgical method were not included because they were not significantly associated with QoL in univariate analyses and showed limited variability within the sample; therefore, their inclusion was unlikely to contribute meaningfully to the explanatory power or stability of the model.

In model 1, the method of paying medical expenses was entered as a control variable. This model was statistically significant (F = 5.40, $p = .006$) and accounted for 6.0% of the variance in QoL ($R^2 = .07$, adjusted $R^2 = .06$). Compared with patients covered by medical insurance, who served as the reference group, self-financed patients reported significantly lower QoL ($\beta = -.21$, $p = .014$), whereas rural insurance was not significantly associated with QoL ($\beta = .13$, $p = .115$).

In model 2, four psychosocial variables derived from the IFSMT, namely self-efficacy, social support, illness perceptions, and resilience, were added. The overall model was statistically significant and explained 70.0% of the variance in QoL ($R^2 = .71$, adjusted $R^2 = .70$). The addition of psychosocial variables produced a significant increase in explanatory power compared with model 1 ($\Delta R^2 = .64$, F = 54.56, $p < .001$).

In the final model, illness perceptions ($\beta = -.61$, $p < .001$), social support ($\beta = .32$, $p < .001$), resilience ($\beta = .20$, $p < .001$), and self-efficacy ($\beta = .19$, $p < .001$) were significantly associated with QoL. After adjustment for these psychosocial variables, the associations between method of paying medical expenses and QoL were no longer statistically significant (rural insurance: $\beta = .06$, $p = .227$; self-financed: $\beta = -.07$, $p = .143$). The standardized regression coefficients represent the expected change in QoL, expressed in SD units, associated with a one-standard-deviation increase in each predictor after adjustment for covariates. Illness perceptions showed the strongest association ($\beta = -.61$), indicating that a one-standard-deviation increase in negative illness perceptions was associated with an approximately 0.61-standard-deviation decrease in QoL. Similarly, higher levels of social support, resilience, and self-efficacy were associated with increases of 0.32, 0.20, and 0.19 SDs in QoL, respectively. These effect sizes correspond to small-to-moderate associations for self-efficacy and resilience and a moderate association for social support, suggesting that variation in these psychosocial factors is meaningfully related to patients' perceived QoL during postoperative recovery.

Overall, psychosocial factors accounted for most of the variance in QoL during the early postoperative period, whereas the independent contribution of financial payment method diminished after these variables were taken into account.

Table 3. Correlations among Study Variables (*N* = 142)

Variables	1	2	3	4	5
			r		
1. Self-efficacy	1				
2. Social support	.08	1			
3. Illness perceptions	–.24**	–.13	1		
4. Resilience	.03	.02	.04	1	
5. Quality of life	.38***	.43***	–.70***	.20*	1
6. Method of paying medical expenses (η)	.17	.15	.10	.20	.27**

Values for variables 1–5 are Pearson correlation coefficients (r). For the categorical variable medical expense payment (1 = medical insurance, 2 = rural insurance, 3 = self-financed), the association with each continuous variable is expressed as eta (η), calculated from one-way analysis of variance.

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 4. Hierarchical Multiple Linear Regression Model Predicting Quality of Life (*N* = 142)

Variables	Categories	Model 1					Model 2				
		B	SE	β	t	*p*	B	SE	β	t	*p*
Constant		3.70	0.20	-	18.62	< .001	2.73	0.38	-	7.28	< .001
Method of paying medical expenses	1. Medical insurance (ref)	-	-	-	-	-	-	-	-	-	-
	2. Rural insurance	0.42	0.27	.13	1.59	.115	0.19	0.15	.06	1.21	.227
	3. Self-financed	–1.80	0.72	–.21	–2.49	.014	–0.63	0.43	–.07	–1.47	.143
Self-efficacy		-	-	-	-	-	0.34	0.09	.19	3.91	< .001
Social support		-	-	-	-	-	0.02	< 0.01	.32	6.72	< .001
Illness perceptions		-	-	-	-	-	–0.04	< 0.01	–.61	–12.65	< .001
Resilience		-	-	-	-	-	0.01	< 0.01	.20	4.13	< .001
R^2				.07					.71		
Adjusted R^2				.06					.70		
F				5.40					54.56		
p				.006					< .001		

ref = reference; SE = standard error.

DISCUSSION

This study aimed to identify factors associated with QoL in CRC patients with a stoma during the early postoperative period, defined as 1 to 6 months after surgery. Overall, the participants reported relatively low QoL, particularly in the physical and social domains, underscoring the substantial challenges faced during early recovery. Guided by the IFSMT, this study identified four psychosocial variables, illness perceptions, social support, resilience, and self-efficacy, as significant correlates of QoL.

The strong association between illness perceptions and QoL highlights the central role of cognitive appraisal in postoperative adaptation. Patients who perceived their condition as less threatening and more controllable reported better QoL, consistent with previous findings in cancer and chronic illness populations [15,31,32]. In the present study, the predominance of married participants and the availability of family support may have contributed to more adaptive illness representations by providing reassurance and practical assistance. These findings suggest that maladaptive illness perceptions are closely associated with poorer perceived QoL. However, because of the cross-sectional design, the direction of this relationship cannot be determined.

Social support emerged as the second strongest predictor of QoL, consistent with earlier studies [14,33]. In this study, social support was derived primarily from spouses and immediate family members, underscoring the central role of the proximal social network during early recovery. This pattern is consistent with the IFSMT framework, which identifies contextual factors such as social support as foundational to the self-management process [9]. At the same time, the concentration of support within the family may suggest a limited breadth of social resources. The univariate association between method of paying medical expenses and QoL further suggests that material and social resources are intertwined and that financial strain may reduce patients' capacity to benefit fully from available support.

Resilience and self-efficacy also showed significant, although relatively modest, associations with QoL. Patients with greater resilience appeared to adapt better to stoma-related challenges, consistent with findings reported by Franjic et al. [16], whereas greater self-efficacy was associated with a stronger sense of competence in daily self-management, in line with previous studies by Xu et al. [11,12]. Although the correlations among social support, resilience, and self-efficacy were modest, each construct remained independently significant in the regression model. This pattern suggests that these variables represent conceptually distinct yet complementary components of postoperative adaptation. Social support reflects external contextual resources that provide emotional reassurance and practical assistance [14]; self-efficacy reflects patients' task-specific confidence in managing stoma care and daily activities [11]; and resilience reflects broader emotional regulation and the ability to recover from stress [16]. Within the IFSMT framework, these resources operate through different mechanisms (i.e., environmental facilitation, behavioral self-regulation, and emotional coping), thereby contributing unique explanatory value even when their bivariate associations are relatively weak [9]. This distinction helps explain why all three variables independently predicted QoL and underscores the importance of addressing multiple psychosocial domains when designing supportive interventions.

Among the demographic and clinical characteristics, only the method of paying medical expenses was associated with QoL in the univariate analysis, and this association weakened after adjustment for psychosocial variables. Self-financed patients reported poorer QoL, reflecting the continuing financial burden of stoma care, including the costs of appliances and follow-up services. This finding is consistent with evidence linking out-of-pocket medical expenditures to reduced QoL in populations with chronic illness [32]. In contrast, clinical variables such as stoma type and surgical method were not associated with QoL and did not provide additional explanatory value in the multivariable models. This pattern suggests that, during the early postoperative phase, subjective appraisal and psychosocial resources may have a stronger relationship with perceived well-being than biomedical characteristics, especially in relatively homogeneous clinical samples.

The large proportion of variance explained by the psychosocial model should be interpreted cautiously. Although the adjusted R^2 is comparable to, or slightly higher than, that reported in similar psychosocial studies of cancer-related QoL [12,31], explaining nearly 70% of the variance with four predictors represents a substantial effect in practical terms. Importantly, the QoL instrument used in this study focused on patients' experiences of living with a stoma and did not include items directly assessing social support, self-efficacy, or resilience, suggesting that the findings are unlikely to be explained simply by content overlap among the measures. Rather, the strong associations observed may reflect the central role of psychosocial adaptation processes in shaping perceived QoL during the early postoperative period, as proposed by the IFSMT framework.

From a clinical perspective, these findings identify several actionable targets for nursing and multidisciplinary interventions. Early postoperative care should include structured psychoeducation and cognitive-behavioral strategies to address maladaptive illness perceptions [15]. Family-inclusive approaches, including training in basic stoma care and supportive communication, may strengthen effective social support [14]. Skills-based training programs supported by visual aids and supervised practice may enhance self-efficacy [11], whereas brief counseling focused on stress management and adaptive coping may help foster resilience [16]. Integrated intervention models that extend from hospital discharge to community follow-up may be particularly beneficial for improving QoL during this vulnerable period [7].

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes causal inference regarding the relationships between psychosocial factors and QoL. Second, excluding patients who were receiving chemotherapy or radiotherapy may limit the generalizability of the results to individuals with a greater disease burden or more complex treatment trajectories. Third, although simple random sampling was used, recruitment through outpatient clinics and voluntary participation may still have introduced selection bias. Fourth, restricting the sample to patients aged 60 years and younger limits the applicability of the findings to older populations, who may differ in psychosocial resources and adaptation patterns. Finally, the exclusive use of self-reported measures raises the possibility of recall and social desirability bias. Future longitudinal, multicenter studies that incorporate objective indicators and broader patient populations are needed to clarify causal pathways and longer-term QoL trajectories following stoma surgery.

CONCLUSION

This study found that CRC patients with a stoma experienced compromised QoL during the early postoperative period, particularly in the physical and social domains. Illness perceptions, social support, resilience, and self-efficacy were strongly associated with QoL and together accounted for a substantial proportion of its variability, highlighting the central role of psychosocial adaptation during this phase of recovery. These findings underscore the importance of moving beyond a purely biomedical focus in postoperative care. Nursing interventions should include strategies to modify maladaptive illness perceptions, strengthen family and social support, enhance patients' confidence in stoma self-management, and promote psychological resilience. Early, structured, and family-inclusive psychosocial support may be especially beneficial in improving patients' perceived well-being after stoma surgery. Future research using longitudinal and multicenter designs is needed to clarify the temporal relationships among psychosocial factors and QoL and to evaluate the effectiveness of theory-based, integrated intervention programs tailored to this vulnerable patient population.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

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FUNDING

This research was funded through a graduate research grant provided by Burapha University, Thailand.

ACKNOWLEDGEMENT

This article is a condensed form of the Bicong Yang's master's thesis from Burapha University. The author thanked the participants in this study and the nurse managers who supported the data collection process.

DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding authors.

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ORIGINAL ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 193-203, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2025.1225

KJAN
Korean Journal of
Adult Nursing

Family Functioning and Environmental Mastery among Breast Cancer Survivors: Serial Mediation by Motivation and Healthy Behaviors

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Received: December 25, 2025
Revised: February 24, 2026
Accepted: March 5, 2026

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Purpose: This study examined the association between family functioning and environmental mastery among breast cancer survivors. Specifically, it tested a serial mediation model involving autonomous motivation and healthy behaviors and compared this pathway with the potential role of controlled motivation. **Methods:** A cross-sectional survey was conducted with 192 community-dwelling Korean breast cancer survivors recruited from an outpatient breast clinic. Participants completed a structured self-administered questionnaire assessing family functioning, autonomous and controlled motivation for self-management, engagement in healthy behaviors, and environmental mastery. Serial mediation was tested using a regression-based bootstrapping approach implemented with Hayes' PROCESS macro. **Results:** Family functioning was positively associated with both healthy behaviors and environmental mastery. The serial indirect effect through autonomous motivation and healthy behaviors was significant (standardized indirect effect, 0.03; 95% bootstrapped confidence interval [BootCI], 0.00–0.06). In addition, healthy behaviors independently mediated the association between family functioning and environmental mastery (standardized indirect effect, 0.11; 95% BootCI, 0.05–0.17). Controlled motivation was not significantly associated with family functioning and did not contribute to indirect effects. **Conclusion:** Supportive family functioning may enhance environmental mastery primarily through greater engagement in healthy behaviors, including a significant sequential pathway involving autonomous motivation. These findings support family-centered, autonomy-supportive approaches that strengthen healthy behaviors to promote psychological adjustment during breast cancer survivorship.

Key Words: Breast neoplasms; Family relations; Health behavior; Psychological adaptation; Motivation

INTRODUCTION

Breast cancer has a high survival rate, with 5-year survival rates now approaching 90% to 91% in many high-income settings, reflecting substantial advances in early detection and treatment [1,2]. Breast cancer survivors frequently face long-term survivorship demands, including persistent treatment-related symptoms (e.g., fatigue, pain, lymphedema), hormonal therapy-related side effects, body image concerns, and ongoing follow-up care, while simultaneously resuming family and work roles [2]. Environmental mastery, one of the key dimensions of psychological well-being proposed by Ryff [3], refers to the perceived competence to manage life demands, utilize available resources, and shape one's circumstances in accordance with personal values and goals. Within the survivorship context, it represents an important indicator of positive psychosocial adaptation [4]. Despite its conceptual relevance, survivorship research has primarily focused on adverse outcomes such as distress and functional impairment, with comparatively less attention devoted to positive adaptation outcomes, including environmental mastery.

Emerging evidence suggests that environmental mastery may be strengthened through sustained engagement in healthy behaviors and supportive interpersonal relationships [4-6]. Engagement in healthy behaviors has been positively associated with environmental mastery, reflecting an increased perceived capacity to manage daily demands and life circumstances [4,5]. Within the cancer survivorship literature, physical activity has been linked to enhanced bodily control and empowerment, which may facilitate broader psychosocial adjustment during recovery [4,6]. Identifying modifiable psychosocial and behavioral pathways that contribute to environmental mastery may therefore inform survivorship care aimed at enhancing daily functioning and long-term quality of life.

Family is a primary source of support for cancer survivors, and family functioning has been identified as a critical determinant of quality of life across multiple domains among families affected by cancer, with effects that may persist as the disease progresses [7,8]. Among breast cancer patients specifically, supportive family functioning characterized by high cohesiveness and expressiveness has been associated with lower psychological distress, whereas conflictual family patterns predict higher levels of depression and anxiety [8,9]. Consistent evidence from breast cancer and broader survivorship research indicates that supportive family functioning is associated with better adjustment and quality of life, whereas conflictual or disengaged family environments are linked to poorer outcomes [7-9]. Nevertheless, the mechanisms linking family functioning to survivors' environmental mastery—defined as the perceived ability to manage and reshape one's environment during survivorship—remain insufficiently understood.

Self-determination theory (SDT) provides a useful framework for explaining how family functioning shapes motivation and, in turn, behavioral and psychosocial outcomes [10]. According to SDT, the quality of motivation underlying behavior can be differentiated into autonomous and controlled forms, depending on whether actions reflect personal values and volition or external pressures, guilt, and contingent rewards [11,12]. Motivational quality is closely linked to the satisfaction of three basic psychological needs—autonomy, competence, and relatedness [12,13]—and family functioning represents an important interpersonal context that can either support or undermine these needs. Adaptive family functioning may support survivors' psychological needs and autonomous motivation by fostering involvement, shared decision-making, and open communication [8-10,14,15]. In contrast, family environments characterized by high conflict and poor problem-solving may undermine need satisfaction and strengthen controlled motivation driven by pressure, obligation, or fear of disappointing family members [8,10]. Accordingly, family functioning can be viewed as a key contextual factor shaping motivational quality and, consequently, an upstream determinant of survivors' healthy behaviors and environmental mastery.

Healthy behaviors are essential for maintaining physical and psychological health throughout cancer survivorship [16]. Active engagement in behaviors such as regular exercise, healthy eating, and stress management may enhance environmental mastery by increasing perceived control over one's health and daily life [12,13]. A substantial body of research highlights the importance of supportive family functioning in the adoption and maintenance of healthy behaviors [17,18]. In addition, several studies have reported associations between both autonomous and controlled forms of motivation and engagement in healthy behaviors and related health outcomes [12,13,16]. However, although controlled motivation may prompt short-term behavior change, it often shows limited sustainability and may negatively affect long-term well-being. It therefore remains unclear whether, and to what extent, these motivational processes account for the association between supportive family functioning and survivors' environmental mastery.

Cancer survivorship requires substantial environmental mastery, as survivors must manage ongoing health needs, navigate complex medical systems, and reorganize daily routines while coping with persistent treatment effects. Despite these theoretical links, few studies of breast cancer survivors have simultaneously examined the sequential pathway from family functioning through motivation and subsequent healthy behaviors to environmental mastery, leaving the psychosocial and behavioral mechanisms underlying this positive adaptation outcome insufficiently specified. The present study therefore examined whether motivation (autonomous and controlled) and healthy behaviors explain the association between family functioning and environmental mastery among breast cancer survivors. Consistent with SDT's proposition that motivation influences sustained behavioral engagement and, through this pathway, broader psychological well-being and development, we tested a sequential mediation model in which motivation relates to healthy behaviors, which in turn relate to environmental mastery as a positive adaptation outcome.

METHODS

1. Research Design

This study used a cross-sectional descriptive design to examine the dual mediating roles of motivation (autonomous and controlled) and healthy behaviors in the association between family functioning and environmental mastery among breast cancer survivors. This study was reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

2. Setting and Samples

In cancer survivorship research, the term "cancer survivor" is broadly defined as any individual from the time of diagnosis through the remainder of life [2]. In this study, breast cancer survivors were operationally defined as community-dwelling women who had completed primary treatment with curative intent and were undergoing routine surveillance and follow-up.

From January 3 to February 23, 2022, participants were recruited by convenience sampling from community-dwelling breast cancer survivors receiving care at the breast clinic of a university hospital in Daejeon, Korea. Eligibility criteria were as follows: (1) female sex, (2) age ≥19 years, (3) histologically confirmed breast cancer diagnosis, (4) completion of primary treatment with curative intent (surgery with or without adjuvant chemotherapy and/or radiotherapy), (5) current follow-up/surveillance status, (6) absence of secondary malignancies, (7) residence in the community (not hospitalized) with family members at the time of enrollment, and (8) sufficient Korean-language proficiency to understand and complete the self-report measures. Long-term adjuvant hormonal therapy, when applicable, was permitted because it is commonly administered during extended survivorship care. Conversely, individuals receiving active primary treatment (e.g., ongoing cytotoxic chemotherapy or radiotherapy for the initial diagnosis) were excluded to ensure a homogeneous post-treatment survivorship sample aligned with the study purpose.

The sample size was calculated using G*Power ver. 3.1.9.4. Assuming a significance level (α) of .05, statistical power ($1-\beta$) of .90, and a medium effect size ($f^2=.15$) identified in a previous study of breast cancer survivors [19], the minimum required sample size was 190, based on a conservative multiple regression model with up to 15 predictors, including the primary study variables and candidate sociodemographic and health-related covariates, and allowing for a 10% dropout rate. A total of 196 participants met the inclusion criteria and completed the survey. After exclusion of four incomplete responses, data from 192 participants were included in the final analysis.

3. Measures

1) Family functioning

Family functioning, defined as the participant's perceived interactions with family members, was measured using the Family Adaptation, Partnership, Growth, Affection, and Resolve scale [20]. The instrument consists of five items assessing adaptation, partnership, growth, affection, and resolve. Each item is rated on a 3-point Likert scale (0 = hardly ever, 1 = some of the time, 2 = almost always), with total scores ranging from 0 to 10; higher scores indicate better family functioning. Internal consistency was Cronbach's $\alpha=.80$ in the original study [20] and Cronbach's $\alpha=.90$ in the present study.

2) Motivation

Motivation for self-management was assessed using the Treatment Self-Regulation Questionnaire (TSRQ) [21], which is grounded in SDT and designed to capture autonomous and controlled motivation. The TSRQ items were framed around engagement in daily self-management behaviors, including diet and exercise, and respondents were asked to indicate the extent to which each reason reflected why they engaged in these behaviors. The instrument comprised 19 items, including 8 assessing autonomous motivation (e.g., personal endorsement and intrinsic value) and

11 assessing controlled motivation (e.g., external pressure or obligation). Each item was rated on a 7-point Likert scale (1 = not at all true to 7 = very true). Mean scores were calculated for the two subscales. In the original validation study, the TSRQ subscales demonstrated acceptable internal consistency (Cronbach's α), ranging from .85 to .93 for autonomous motivation, .74 to .86 for introjected regulation, and .73 to .91 for external regulation [21]. In the present study, Cronbach's α was .91 for autonomous motivation and .76 for controlled motivation (composite of introjected and external regulation).

3) Healthy behaviors

Healthy behaviors were measured using the Health-Promoting Lifestyle Profile II (HPLP-II) [22]. The instrument comprises 52 items across six subdomains: health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management. Items are rated on a 4-point Likert scale (1 = not at all to 4 = always), and mean scores are calculated, with higher scores indicating greater engagement in healthy behaviors. The original HPLP-II demonstrated good internal consistency (Cronbach's α = .94) [22], and internal consistency in the present study was Cronbach's α = .95.

4) Environmental mastery

Environmental mastery was measured using the Environmental Mastery subscale of the Psychological Well-Being Scale [3,23]. This scale assesses the subjective sense of control and efficacy in managing one's life conditions and surrounding contexts, encompassing the various demands, resources, and circumstances encountered in daily life. It consists of eight items rated on a 6-point Likert scale (1 = not at all true to 6 = very true). Higher scores indicate a greater ability to manage and control one's environment effectively. Internal consistency was Cronbach's α = .82 in the original study [3] and Cronbach's α = .71 in the present study.

5) Sociodemographic and health-related characteristics

Sociodemographic characteristics included age, presence of a spouse (yes/no), educational level (high school or below vs. college or beyond), current employment status (yes/no), and monthly household income (measured in units of 10,000 Korean won [KRW]). Health-related characteristics included comorbidity, cancer treatment history, and subjective health status. Comorbidity was defined as the presence of at least one physician-diagnosed chronic condition (e.g., hypertension, diabetes, dyslipidemia, arthritis, or other chronic illnesses) and was coded dichotomously (yes/no). Cancer treatment history was assessed as a multiple-response item (mastectomy, chemotherapy, radiotherapy, hormonal therapy, targeted therapy, or other treatments). Subjective health status was assessed using a 5-point Likert scale (1 = very poor to 5 = very good).

4. Procedure

A research investigator stationed in the outpatient department approached potential participants and confirmed their willingness to participate. A breast cancer coordinator nurse then screened individuals who expressed interest to verify the absence of cancer recurrence or metastasis, after which they were enrolled in the study.

5. Ethical Considerations

This study was approved by the Institutional Review Board of Chungnam National University (No. 202101-SB-009-01). Participants were informed about the study purpose and procedures, the voluntary nature of participation, the assurance of anonymity, and the exclusive use of collected information for research purposes. They were also informed that they could discontinue participation at any time and withdraw from the study after completion without disadvantage. Data were collected after written informed consent was obtained, and participants completed the structured self-administered questionnaire in a quiet, private space within the center to ensure independent responses. Upon completion of the survey, participants received a KRW 5,000 gift voucher as a token of appreciation.

6. Statistical Analysis

Data were analyzed using IBM SPSS ver. 29.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participants' general characteristics, and the reliability of each measurement instrument was evaluated using Cronbach's alpha coefficients. Pearson correlation analysis was conducted to examine the relationships among the main variables, including family functioning, motivation (autonomous and controlled), healthy behaviors, and environmental mastery.

Before the mediation analyses, key regression assumptions were evaluated. Multicollinearity among the independent variable (family functioning), mediators (autonomous or controlled motivation and healthy behaviors), and covariates (e.g., age, subjective health status, and cancer treatment history) was assessed using tolerance and variance inflation factor (VIF) statistics, with tolerance $>.10$ and VIF <10 as diagnostic thresholds [24]. Independence of residuals was examined using the Durbin–Watson statistic, with values close to 2 indicating no first-order autocorrelation [24]. Homoscedasticity was evaluated by examining residual plots for systematic patterns. All assumptions were adequately met, supporting the validity of the subsequent inferential analyses.

The serial mediation effects of motivation (autonomous and controlled) and healthy behaviors on the relationship between family functioning and environmental mastery were tested using Hayes' PROCESS macro Model 6 for SPSS. PROCESS Model 6 provides estimates of the specific indirect effect for each mediating pathway as well as the total indirect effect, defined as the sum of all specific indirect effects. Accordingly, indirect effects by pathway (specific indirect effects) and the total indirect effect were reported separately. Statistical significance was evaluated using 5,000 bootstrap samples, and mediation effects were considered significant when the 95% confidence interval (CI) did not include zero.

RESULTS

1. Sociodemographic and Health-Related Characteristics and Their Association with Environmental Mastery

The mean age of the participants was 51.60 years (standard deviation [SD], 7.95 years), with a range of 32 to 69 years. Most participants had a spouse. Regarding educational attainment, 49.5% had a college degree or higher, whereas 50.5% had completed high school or less. Approximately 45.8% were currently employed, and 47.4% reported a monthly household income exceeding 4 million KRW.

Regarding health-related characteristics, 28.6% of participants reported having chronic diseases, and the mean subjective health status score was 3.06 (SD, 0.85; range, 1–5). For breast cancer treatment history, mastectomy was the most common treatment (86.5%), followed by hormonal therapy (36.5%), chemotherapy (4.7%), radiotherapy (2.6%), and targeted or other therapies (3.1%).

Environmental mastery differed significantly according to age ($r=.25$, $p=.001$), subjective health status ($r=.38$, $p<.001$), and history of chemotherapy ($t=2.23$, $p=.027$) (Table 1).

2. Intercorrelations among Study Variables

Pearson correlation analyses revealed significant associ-

Table 1. Sociodemographic and Health-Related Characteristics of the Participants and Differences in Environmental Mastery ($N=192$)

Variables	Categories	M ± SD or n (%)	Environmental mastery
			t or r (p)
Age (year)		51.60 ± 7.95	.25 (.001)
Presence of a spouse	Yes	170 (88.5)	–0.17 (.862)
Educational level	High school or below	97 (50.5)	0.40 (.693)
	College or beyond	95 (49.5)	
Currently employed	Yes	88 (45.8)	–1.16 (.249)
Monthly household income (10,000 KRW)	≤ 400	101 (52.6)	–1.45 (.150)
	> 400	91 (47.4)	
Subjective health status		3.06 ± 0.85	.38 (< .001)
Comorbidity	Yes	55 (28.6)	–0.32 (.752)
Cancer treatment history	Mastectomy	166 (86.5)	0.84 (.400)
	Hormonal therapy	70 (36.5)	–0.24 (.813)
	Chemotherapy	9 (4.7)	2.23 (.027)
	Radiotherapy	5 (2.6)	–0.48 (.635)
	Targeted or other therapies	6 (3.1)	–0.64 (.523)

Cancer treatment history was a multiple-response item. Only affirmative categories are presented for binary variables. Multiple responses were allowed for cancer treatment history; categories indicate treatments ever received after diagnosis.
KRW = Korean won (monthly household income was measured in units of 10,000 KRW); M = mean; SD = standard deviation.

ations among the key study variables (Table 2). Family functioning was significantly correlated with autonomous motivation (r = .20, $p = .005$), healthy behaviors (r = .44, $p < .001$), and environmental mastery (r = .47, $p < .001$). Healthy behaviors were significantly positively correlated with both autonomous motivation (r = .56, $p < .001$) and controlled motivation (r = .17, $p = .020$), as well as with environmental mastery (r = .56, $p < .001$). Autonomous motivation was significantly correlated with environmental mastery (r = .32, $p < .001$), and autonomous and controlled motivation were significantly correlated with each other (r = .39, $p < .001$).

3. Serial Mediation Effects of Autonomous Motivation and Healthy Behaviors in the Relationship between Family Functioning and Environmental Mastery

Multicollinearity diagnostics were acceptable, with tolerance values ranging from .55 to .99 and VIF values ranging from 1.02 to 1.83 [24]. The Durbin–Watson statistic was 1.90, which is close to 2.0 and indicates negligible autocorrelation [24]. Residual plots confirmed homoscedasticity. All regression assumptions were adequately met. Table 3 presents the indirect and serial indirect effects of family functioning on environmental mastery through autonomous motivation and subsequent healthy behaviors. The sequential indirect effect through autonomous motivation and healthy behaviors was significant (standardized indirect effect, 0.03; 95% bootstrapped CI [BootCI], 0.00–0.06), indicating a serial mediation pathway. In addition, the indirect effect of family functioning on environmental mastery through autonomous motivation alone was not significant (standardized indirect effect, 0.00; 95% BootCI, –0.02 to 0.03), whereas the indirect effect through healthy behaviors was significant (standardized indirect effect, 0.11; 95% BootCI, 0.05–0.17).

Figure 1 illustrates the direct effect of family functioning on environmental mastery and the serial indirect effects through autonomous motivation and healthy behaviors. After adjustment for covariates (age, subjective health status, mastectomy, and chemotherapy), family functioning significantly predicted autonomous motivation (β = .16,

Table 2. Correlations among Main Study Variables ($N = 192$)

Variables	Mean ± SD	1	2	3	4
		r (p)			
1. Family functioning	8.20 ± 2.39	-			
2. Autonomous motivation	5.83 ± 1.17	.20 (.005)	-		
3. Controlled motivation	3.68 ± 1.34	-.00 (.988)	.39 (< .001)	-	
4. Healthy behaviors	2.97 ± 0.48	.44 (< .001)	.56 (< .001)	.17 (.020)	-
5. Environmental mastery	4.52 ± 0.71	.47 (< .001)	.32 (< .001)	-.00 (.962)	.56 (< .001)

SD = standard deviation.

Table 3. Specific and Total Indirect Effects of Family Functioning on Environmental Mastery through Motivation and Healthy Behaviors ($N = 192$)

Indirect paths	Standardized indirect effect	BootSE	95% BootCI
Autonomous motivation			
Ind1: Family → Autonomous motivation → Environmental mastery	0.00	0.01	–0.02 to 0.03
Ind2: Family → Healthy behaviors → Environmental mastery	0.11	0.03	0.05 to 0.17
Ind3: Family → Autonomous motivation → Healthy behaviors → Environmental mastery	0.03	0.02	0.00 to 0.06
Total indirect effect (sum of Ind1–Ind3)	0.14	0.04	0.07 to 0.21
Controlled motivation			
Ind1: Family → Controlled motivation → Environmental mastery	0.00	0.01	–0.01 to 0.02
Ind2: Family → Healthy behaviors → Environmental mastery	0.14	0.04	0.08 to 0.22
Ind3: Family → Controlled motivation → Healthy behaviors → Environmental mastery	0.00	0.00	–0.01 to 0.01
Total indirect effect (sum of Ind1–Ind3)	0.14	0.04	0.08 to 0.22

Indirect effects are reported as standardized indirect effects (PROCESS estimate: *ab_cs*), based on 5,000 bootstrap resamples with 95% BootCIs. Covariates were age, subjective health status, and cancer treatment history (mastectomy and chemotherapy).
BootCI = bootstrap confidence interval; BootSE = bootstrap standard error; Ind = indirect pathway.

$p = .037$), healthy behaviors ($\beta = .30$, $p < .001$), and environmental mastery ($\beta = .24$, $p < .001$). Autonomous motivation significantly predicted healthy behaviors ($\beta = .47$, $p < .001$) but not environmental mastery ($\beta = .02$, $p = .801$), whereas healthy behaviors significantly predicted environmental mastery ($\beta = .36$, $p < .001$).

4. Serial Mediation Effects of Controlled Motivation and Healthy Behaviors in the Relationship between Family Functioning and Environmental Mastery

Figure 2 presents the direct and indirect effects of family functioning on environmental mastery through controlled motivation and healthy behaviors. After adjustment for co-

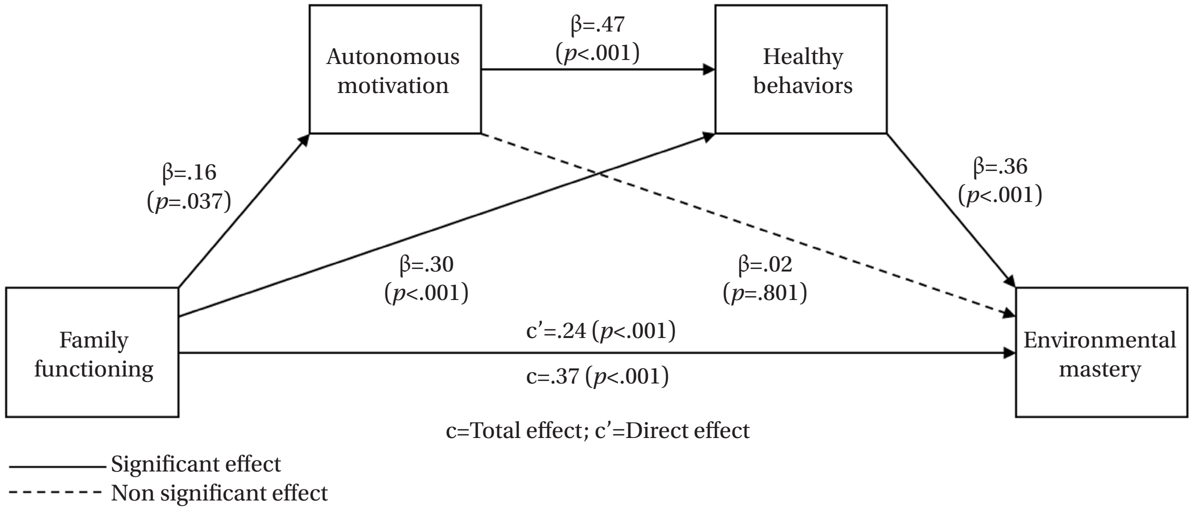

Figure 1. Serial mediation model of the association between family functioning and environmental mastery through autonomous motivation and healthy behaviors. Standardized regression coefficients are presented. Autonomous motivation (M1) and healthy behaviors (M2) were specified as serial mediators of the effect of family functioning on environmental mastery. Age, subjective health status, and cancer treatment history (mastectomy and chemotherapy) were included as covariates.

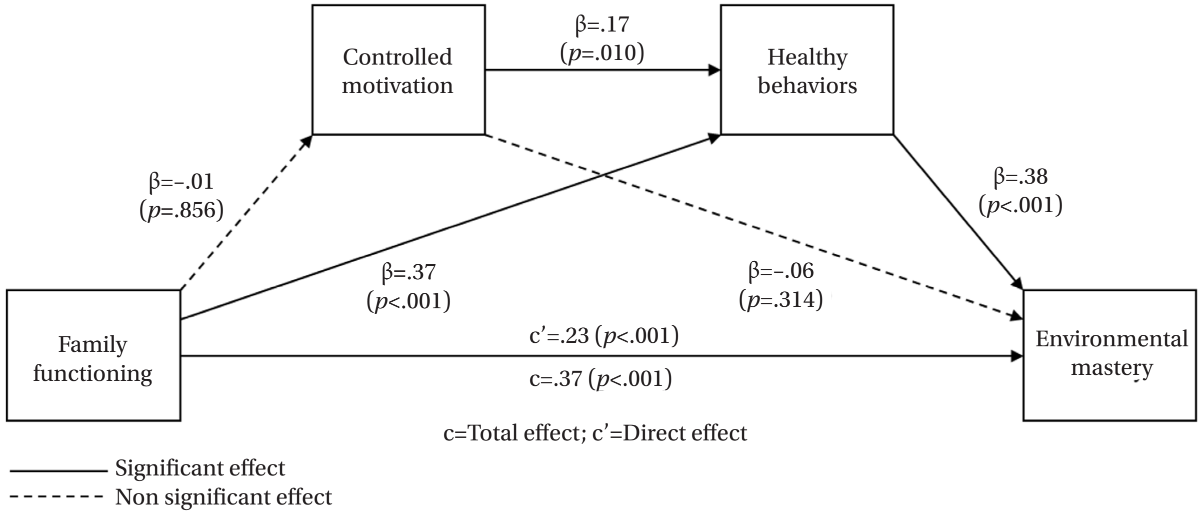

Figure 2. Serial mediation model of the association between family functioning and environmental mastery through controlled motivation and healthy behaviors. Standardized regression coefficients are presented. Controlled motivation (M1) and healthy behaviors (M2) were specified as serial mediators of the effect of family functioning on environmental mastery. Age, subjective health status, and cancer treatment history (mastectomy and chemotherapy) were included as covariates.

variates, family functioning did not significantly predict controlled motivation (β = –.01, *p* = .856) but did significantly predict healthy behaviors (β = .37, *p* < .001) and environmental mastery (β = .23, *p* < .001). Controlled motivation significantly predicted healthy behaviors (β = .17, *p* = .010) but not environmental mastery. This indicates that controlled motivation did not function as a mediator, whereas healthy behaviors remained a significant pathway linking family functioning to environmental mastery (Table 3).

DISCUSSION

Understanding how breast cancer survivors actively manage their living environments and sustain environmental mastery throughout survivorship is essential for clarifying psychological well-being. Grounded in SDT, this study examined how family functioning was associated with environmental mastery through the serial mediating effects of autonomous and controlled motivation and healthy behaviors among breast cancer survivors.

A key finding was that family functioning was indirectly associated with environmental mastery through a sequential pathway involving autonomous motivation and healthy behaviors. This pattern is consistent with SDT's proposition that supportive interpersonal contexts facilitate autonomous motivation, which in turn promotes engagement in healthy behaviors [12,16]. This finding is also consistent with evidence that adaptive family functioning is associated with greater autonomous motivation, healthier behaviors, and better psychological well-being [8,25]. Extending this literature, the present findings suggest a serial pathway linking family functioning to environmental mastery through autonomous motivation and healthy behaviors, thereby highlighting their relevance to survivors' perceived capacity to manage and organize life circumstances.

Healthy behaviors emerged as a central mediator in the serial pathway. Family functioning showed a direct association with healthy behaviors beyond the motivational pathways, suggesting that families may facilitate healthy behaviors through additional mechanisms, such as practical assistance, encouragement, and behavioral modeling [17,18]. This interpretation is supported by evidence that family participation in decision-making and communication supports sustained engagement in healthy behaviors [7,9,15]. Taken together, these findings suggest that supportive family environments may provide both emotional affirmation and concrete resources that help survivors establish healthy behaviors, thereby strengthening environmental mastery.

Consistent with SDT propositions and empirical evidence regarding the influence of motivation on behavioral engagement [11,12,16], both autonomous and controlled motivation were associated with healthy behaviors. However, contrary to the initial expectation, neither autonomous nor controlled motivation independently mediated the association between family functioning and environmental mastery. Autonomous motivation contributed only as part of the serial pathway through healthy behaviors, indicating that self-endorsed motives may be necessary but not sufficient in the absence of behavioral enactment. This interpretation supports prior work showing that behavioral engagement is a key pathway linking motivational quality to psychological well-being [13,16]. In the present study, motivation was associated with environmental mastery primarily through engagement in healthy behaviors, underscoring the importance of behavioral implementation in survivors' perceived environmental mastery. Notably, this finding differs from some previous studies in which motivational regulation showed more direct associations with well-being outcomes such as depression and anxiety [13,16,26]. This difference may reflect the nature of the outcome examined. Environmental mastery, which encompasses the ability to manage and organize one's living environment, may depend more on behavioral enactment than on motivational state alone.

In contrast, pathways involving controlled motivation were more limited than expected. Controlled motivation showed only a small association with healthy behaviors and was neither directly nor indirectly associated with environmental mastery. These findings are consistent with previous evidence indicating that controlled motivation (e.g., fear of recurrence, external pressure, perceived expectations) may support compliance-focused engagement in healthy behaviors but may be less likely to translate into sustained gains in psychological well-being or positive adaptation [11,13,16,26]. This pattern suggests that externally driven motivation may promote temporary compliance but has limited value for long-term adaptive outcomes related to environmental mastery. Taken together, these findings suggest that supportive family functioning may be most beneficial when it fosters autonomous motivation and enables sustained engagement in healthy behaviors.

Several limitations should be noted. First, the cross-sectional design precludes causal inference, and although healthy behaviors were modeled as antecedents of environmental mastery, reverse or reciprocal relationships are plausible. Longitudinal studies are needed to clarify temporal ordering. Second, the self-reported measures may be subject to recall and social desirability bias, and healthy behaviors were assessed as perceived engagement rather than with objective measures. Third, family functioning was assessed only from the survivors' perspective, which limits insight into dyadic or systemic patterns. Previous research suggests that family members may hold divergent perceptions of family functioning [9,27] and that typological patterns, including supportive, conflictual, and intermediate traits [9,10,14], may differentially predict outcomes. Future research should adopt longitudinal, multi-informant designs and incorporate objective measures of healthy behaviors and family functioning to clarify temporal and reciprocal relationships among the study variables. It would also be valuable to examine whether different family functioning profiles show distinct motivational and behavioral pathways to environmental mastery.

This study contributes to the literature by focusing on environmental mastery, a key dimension of long-term adaptation in cancer survivorship, and by delineating how family functioning, motivation, and healthy behaviors operate together in relation to this outcome. Autonomous motivation was associated with environmental mastery primarily through healthy behaviors, whereas controlled motivation showed limited influence on environmental mastery. These findings highlight the value of interventions that strengthen family functioning, foster autonomous motivation, and support sustained engagement in healthy behaviors as strategies to enhance environmental mastery among breast cancer survivors.

CONCLUSION

This study investigated the pathways linking family functioning with environmental mastery through autonomous and controlled motivation and healthy behaviors among breast cancer survivors. The main finding was that family functioning was indirectly associated with environmental mastery through a sequential pathway involving autonomous motivation and healthy behaviors, with healthy behaviors emerging as the primary mediator in this association. In contrast, controlled motivation contributed modestly to healthy behaviors but showed no association with environmental mastery, indicating that motivational quality, rather than its mere presence, may be central to positive psychological well-being in this population.

These findings suggest that enhancing environmental mastery among breast cancer survivors may require an integrated approach that strengthens family functioning, fosters autonomous motivation, and facilitates sustained engagement in healthy behaviors. Nursing practice should incorporate multicomponent interventions that engage families, support survivors' autonomy, and promote adherence to healthy behaviors to enhance environmental mastery and long-term psychological well-being in breast cancer survivorship. Future research should evaluate family- and motivation-focused interventions and clarify how changes in family functioning, motivation, and healthy behaviors relate to changes in environmental mastery over time.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design acquisition - HEY, SS, and HL; methodology - HEY and SS; investigation - SS and HL; formal analysis - HEY and SS; validation - HEY and SS; supervision - HEY; project administration - HEY; funding acquisition - HEY; drafting and critical revision of the manuscript - HEY, SS, and HL.

FUNDING

This study was supported by Chungnam National University Research Funds.

ACKNOWLEDGEMENT

None.

DATA AVAILABILITY STATEMENT

Participants did not provide consent for public open sharing of their individual-level data. Consequently, the datasets are not publicly available. De-identified data may be obtained from the corresponding author upon reasonable request, subject to institutional review and a data use agreement.

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ORIGINAL ARTICLE

Korean J Adult Nurs Vol. 38 No. 2, 204-215, May 2026
eISSN: 2288-338X
https://doi.org/10.7475/kjan.2026.0105

KJAN
Korean Journal of
Adult Nursing

Development and Evaluation of a Patient-Tailored Bowel Preparation Program among Adults Scheduled for Colonoscopy: A Quasi-Experimental, Nonequivalent Control Group Study

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Received: January 5, 2026
Revised: May 13, 2026
Accepted: May 15, 2026

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Purpose: Inadequate bowel preparation compromises the efficacy of colonoscopy. This study aimed to develop and evaluate a patient-tailored bowel preparation program designed to improve bowel preparation quality, medication adherence, and dietary adherence among patients undergoing colonoscopy. **Methods:** The program consisted of four phases: (1) patient-specific assessment using a checklist; (2) personalized instructional videos; (3) short message service reminders; and (4) nurse-led counseling. A quasi-experimental, nonconcurrent nonequivalent control group, posttest-only design was used, with the control group recruited first. The study was conducted from April to July 2024 at a tertiary hospital in South Korea and included 80 adult outpatients scheduled for colonoscopy (40 control and 40 experimental participants). Outcomes included bowel preparation quality assessed using the Aronchick Bowel Preparation Scale, medication knowledge and adherence, and dietary knowledge and adherence. **Results:** The experimental group demonstrated significantly higher bowel preparation quality than the control group ($Z=8.13$, $p<.001$, $r=0.91$). Medication knowledge and adherence were also significantly higher in the experimental group than in the control group ($Z=3.54$, $p<.001$, $r=0.40$; $Z=6.50$, $p<.001$, $r=0.73$; respectively). Similarly, dietary knowledge and adherence improved significantly in the experimental group compared with the control group ($Z=5.28$, $p<.001$, $r=0.59$; $Z=5.32$, $p<.001$, $r=0.60$; respectively). **Conclusion:** The patient-tailored bowel preparation program effectively improved bowel preparation outcomes for colonoscopy. Future research should focus on integrating the program into electronic health records to enable automated delivery and improve efficiency and scalability in clinical practice.

Key Words: Patient-centered care; Colonoscopy; Laxatives; Nursing care

INTRODUCTION

As one of the leading causes of cancer-related mortality, colorectal cancer requires effective screening strategies, with colonoscopy considered the most reliable method for early detection and prevention [1,2]. Colonoscopy is regarded as the gold standard for colorectal cancer screening because it enables not only the early detection of malignancies but also the removal of precancerous adenomas before malignant transformation occurs [1,2]. In addition, colonoscopy facilitates therapeutic interventions, such as hemostasis for lower gastrointestinal bleeding, further underscoring its diagnostic and therapeutic value [3]. However, the effectiveness of colonoscopy depends heavily on adequate bowel preparation because inadequate cleansing impairs mucosal visualization, prolongs procedure time, increases complication risk, and reduces the adenoma detection rate by up to 20% [4]. Recognizing these implications, the U.S. Multi-Society Task Force recommends adequate bowel preparation in at least 85% of procedures, whereas European guidelines recommend a higher benchmark of 90%, both assessed using validated scales [5,6]. Therefore, optimizing bowel preparation is essential for ensuring the diagnostic accuracy and overall effectiveness of colonoscopy.

Although adequate bowel preparation is essential for successful colonoscopy, the reported rate of inadequate bowel cleansing ranges from 16.9% to 50.0% [7]. Several factors contribute to inadequate preparation, including sociodemographic characteristics such as older age, male sex, and obesity, as well as medical conditions including inpatient status, constipation, liver disease, hypertension, diabetes, and stroke [7]. A recent prospective study identified male sex, diabetes, constipation, previous colorectal surgery, consumption of a high-fiber diet within 24 hours before colonoscopy, and a bowel preparation-to-procedure interval exceeding 5 hours as independent risk factors for inadequate bowel preparation [8]. These findings highlight the importance of patient-tailored approaches that account for individual medical conditions and age-related factors to improve bowel preparation efficacy and overall colonoscopy outcomes. In Korean clinical settings, suboptimal bowel preparation has been reported in approximately one-third of colonoscopies, with older age and comorbidity burden identified as major contributing factors, further supporting the need for risk-informed educational support [9].

Systematic reviews have identified several interventions aimed at improving bowel preparation quality, including paper-based educational materials, video-based education, and telephone-based re-education [10,11]. More recently, technology-based approaches, such as mobile applications and virtual reality, have been explored as innovative strategies to improve bowel cleansing efficacy [12]. However, printed materials typically provide standardized content without accounting for patient-specific characteristics, such as age or comorbidities [13], whereas technology-based education may be less accessible to older adults, who represent a substantial proportion of patients undergoing colonoscopy [14]. South Korean intervention studies have similarly reported benefits from reinforced education delivered near key preparation milestones. For example, telephone- or short message service (SMS)-based re-education shortly before colonoscopy improved bowel preparation quality compared with usual instruction [15]. In nursing-led education studies, patient educational video programs improved knowledge, adherence, and bowel cleanliness [16]. Collectively, these previous approaches were largely limited to single-modality interventions and did not systematically integrate risk stratification with multimodal reinforcement throughout the preprocedural period, highlighting the need for a more structured patient-tailored program.

Given these limitations, there is an increasing need for patient-tailored bowel preparation education that accounts for individual factors, including age, underlying medical conditions, bowel preparation agents, and recommended split-dose regimens [17]. Recent studies have demonstrated the effectiveness of personalized educational interventions in which specialized nurses tailor educational content according to patients' health literacy, medical history, prescribed medications, and age [18]. These tailored interventions have shown superior outcomes in bowel preparation quality and adherence compared with conventional approaches [18]. Building on this evidence, the present study aimed to develop a patient-tailored bowel preparation program (PTBPP) and evaluate its effectiveness. The primary outcome was bowel preparation quality. Secondary outcomes included patients' knowledge of and adherence to bowel preparation medications, as well as their knowledge of and adherence to dietary recommendations related to bowel preparation.

METHODS

1. Development and Configuration of the PTBPP

The PTBPP was developed as a four-phase intervention to optimize colonoscopy preparation through patient-specific assessment, personalized instructional videos, SMS reminders, and real-time nurse-led counseling [6].

1) Development process and expert validation

The content of this tailored framework was based on a comprehensive literature review. Searches were conducted in PubMed, Google Scholar, and RISS, identifying five systematic reviews and guidelines [6,19-22] and one reference textbook [23]. The PTBPP clinical protocols were aligned with the European Society of Gastrointestinal Endoscopy (ESGE) 2019 guidelines and the Korean Guidelines for Postpolypectomy Colonoscopic Surveillance (2022) to ensure regional clinical relevance and safety within the Korean medical context.

The content validity of the preliminary program was evaluated by a panel of five experts, including three gastroenterologists and two endoscopy nurses, using a 4-point Likert scale. Validation included 26 items across three domains: (1) the patient-specific assessment checklist (10 items); (2) personalized instructional videos (8 items); and (3) SMS-based educational reinforcement (8 items). The Item-Content Validity Index (I-CVI) ranged from 0.80 to 1.00 across all domains, and the overall Scale-level Content Validity Index (S-CVI/Ave) was 0.96, indicating high content validity.

Based on expert feedback, the medication-management instructions were revised by replacing the fixed cessation period for antithrombotic agents with a requirement for mandatory confirmation from the prescribing physician to prevent clinical complications. In addition, the timing of counseling phone calls was advanced from 1 day before to 2 days before the procedure, ensuring that patients had sufficient time for dietary adjustment and bowel preparation.

2) Final configuration of the PTBPP

The final PTBPP was structured around an operational logic that systematically linked individual assessment data to subsequent intervention components, ensuring that all educational content and counseling were aligned with each participant's clinical profile (Figure 1).

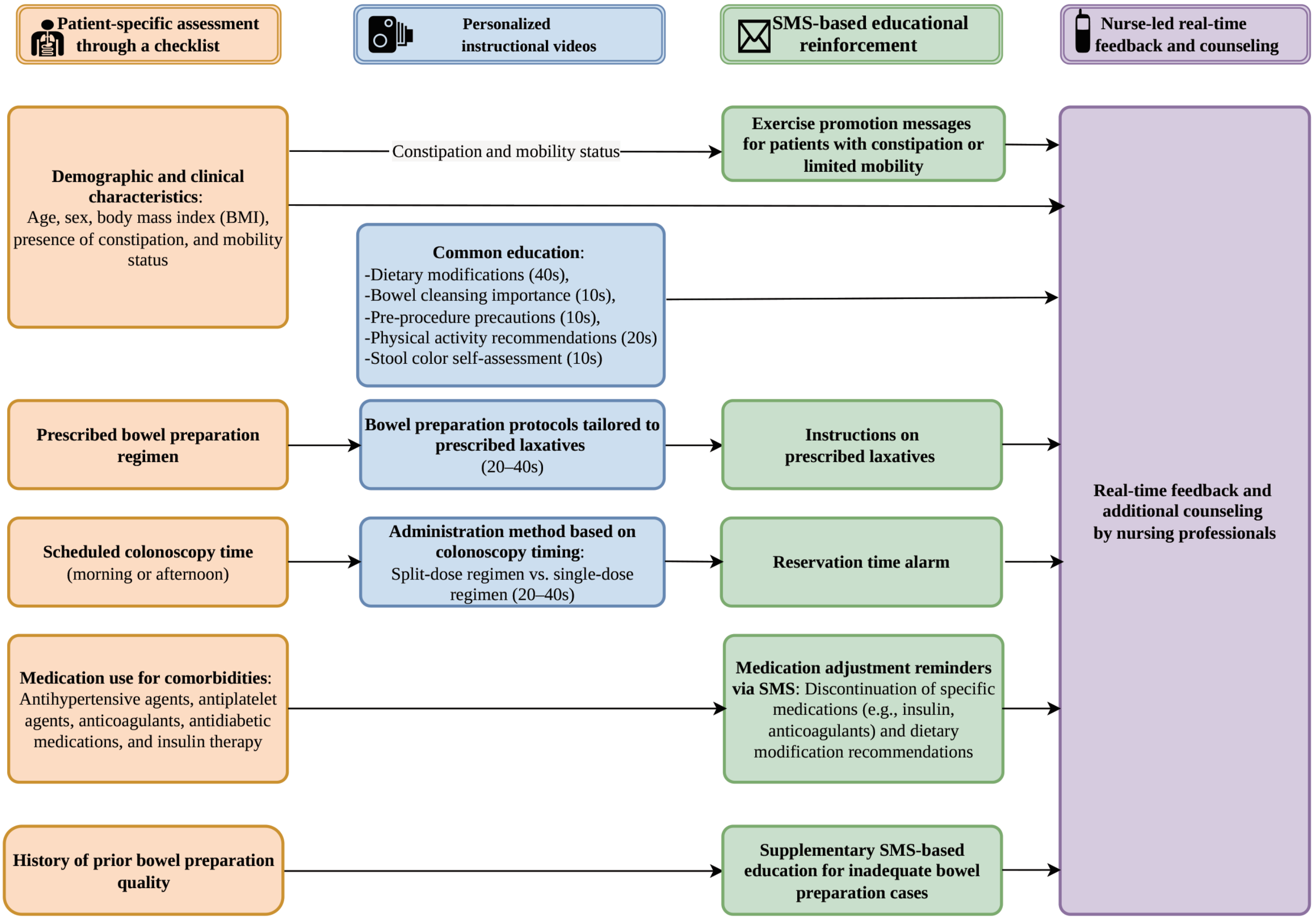

Figure 1. Configuration of the patient-tailored bowel preparation program. SMS = short message service.

https://doi.org/10.7475/kjan.2026.0105

(1) Phase 1: patient-specific assessment through a checklist

The first phase involved developing a pre-colonoscopy checklist to identify individual patient characteristics and clinical risk factors, including age, bowel habits, mobility, comorbidities, and previous experiences [6]. These assessment results served as the primary input data for customizing the subsequent phases. Specifically, a predefined mapping logic was applied: the prescribed agent and procedure timing determined the video selection in phase 2; chronic constipation or a history of inadequate preparation triggered intensified SMS reinforcement in phase 3; and individual risk factors provided the basis for phase 4 telephone counseling. The detailed operational mapping of these variables to each intervention component is presented in Supplementary Table 1.

(2) Phase 2: personalized instructional videos

The second phase involved developing and disseminating personalized educational videos tailored to individual patient characteristics [10]. The PTBPP included seven video modules: five standardized educational videos and two individualized videos. The standardized videos covered the importance of bowel cleansing, dietary modifications, medications requiring special precautions, physical activity recommendations after bowel preparation, and stool color self-assessment to determine bowel cleansing adequacy. The individualized videos provided bowel preparation instructions according to the prescribed bowel cleansing agent and colonoscopy timing (morning vs. afternoon), ensuring that patients received an appropriate split-dose or single-dose regimen.

The video guides for bowel preparation regimens were tailored according to the prescribed laxative type and scheduled colonoscopy time and ranged from 20 to 40 seconds. The common educational videos, which addressed dietary modifications and general bowel preparation guidelines, ranged from 10 to 40 seconds. Each participant received a personalized set of seven videos with a total duration of 2 minutes to 3 minutes 40 seconds.

(3) Phase 3: SMS-based educational reinforcement

The third phase focused on improving adherence through personalized SMS reminders [15]. Text messages were tailored to each patient's prescribed bowel preparation agent, scheduled colonoscopy time, and comorbid conditions. These messages included medication-specific instructions; guidance on discontinuing antihypertensive agents, antidiabetic medications, anticoagulants, and antiplatelet drugs; and insulin suspension protocols. Personalized SMS reminders were delivered beginning 7 days before colonoscopy, with each participant receiving 2 to 3 messages during this period. Patients with a history of inadequate bowel preparation also received supplementary SMS reminders with tailored bowel-cleansing instructions to improve adherence.

(4) Phase 4: nurse-led real-time feedback and counseling

The fourth phase involved real-time feedback and individualized counseling conducted by an experienced endoscopy nurse via telephone 2 days before the procedure [24]. Using a standardized counseling and assessment sheet derived from the phase 1 checklist data, the nurse verified adherence to the bowel preparation protocol and provided individualized guidance. This guidance included confirmation of the prescribed laxative regimen, including timing and dosage; verification of medication adjustments for comorbidities, such as antihypertensive, antidiabetic, and insulin therapies, with mandatory physician confirmation for antithrombotic cessation; reinforcement of dietary restrictions; and intensified support for high-risk patients, including those with chronic constipation or a history of inadequate preparation (Supplementary Table 1). Active listening techniques were used to address patient concerns and enhance engagement.

2. Verification of the PTBPP

1) Study design

This study used a quasi-experimental, nonconcurrent nonequivalent control group, posttest-only design to evaluate the effects of the PTBPP on bowel preparation quality, knowledge of and adherence to laxatives, and dietary knowledge and adherence (Supplementary Figure 1). Because the control group was recruited and assessed first, followed by the intervention group, this nonconcurrent design was used to minimize contamination.

Three hypotheses were tested. First, patients who participated in the PTBPP were hypothesized to demonstrate significantly different bowel preparation quality compared with those who received usual paper-based education (hypothesis 1). Second, patients who participated in the PTBPP were hypothesized to demonstrate significantly different knowledge of and adherence to bowel preparation medications compared with those who received usual paper-based education (hypothesis 2). Third, patients who participated in the PTBPP were hypothesized to demonstrate significantly different knowledge of and adherence to dietary recommendations for bowel preparation compared with those who received usual paper-based education (hypothesis 3).

Participants in both groups received a standardized explanation of the overall study procedures for bowel preparation education and colonoscopy. However, they were not explicitly informed of their assigned study group, namely, usual paper-based education or the PTBPP.

2) Setting and participants

This study was conducted from April to July 2024 at a 1,130-bed tertiary teaching hospital in Gwangju, South Korea. Participants were recruited from the gastroenterology outpatient clinic among patients scheduled for colonoscopy during the study period. Eligible participants were adults aged 19 years or older who were scheduled to undergo colonoscopy. The exclusion criteria were as follows: (1) diagnosed psychiatric disorder; (2) documented cognitive impairment, such as dementia or delirium, or communication difficulties that precluded informed consent or completion of study procedures; and (3) inability to complete any component of the PTBPP.

The sample size was calculated using G*Power 3.1.9.7 (Heinrich Heine University Dusseldorf, Dusseldorf, Germany). An a priori power analysis was conducted using the Wilcoxon-Mann-Whitney test. Based on the meta-analytic effect size ($d=0.66$) of educational video interventions [10], 80% statistical power, and a two-tailed significance level of 5%, the required sample size was 76 participants (38 per group). To accommodate an estimated dropout rate of approximately 15%, the final target sample size was set at 88 participants.

A total of 120 participants were screened for eligibility. Thirty-two were not enrolled: 10 did not meet the inclusion criterion of age ≥19 years, 14 had scheduling conflicts, and eight had difficulty using a smartphone. After eligibility assessment, 40 participants were allocated to the control group and 48 to the experimental group. In the experimental group, 8 participants withdrew after allocation because of lack of interest, resulting in 40 participants who completed the study and were included in the analysis (Figure 2).

3) Measurements/instruments

Bowel-preparation–related baseline variables were selected a priori with reference to the 2019 ESGE guideline update [6], and demographic characteristics were collected as routine baseline information.

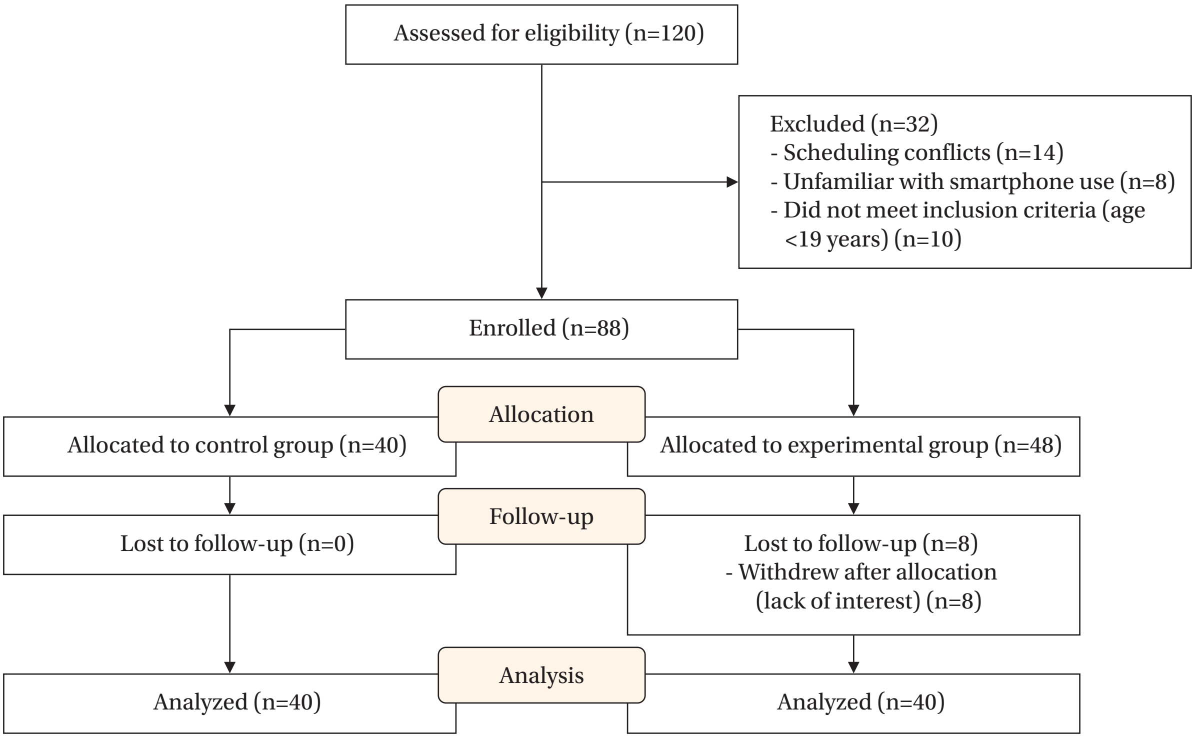

Figure 2. Flow diagram of participants through the study.

Bowel cleansing quality was assessed using the Aronchick Bowel Preparation Scale (ABPS), a validated tool recommended by the U.S. Multi-Society Task Force on Colorectal Cancer for evaluating bowel preparation adequacy [5,25]. The ABPS categorizes bowel preparation into five levels: excellent (5 points), good, fair, poor, and inadequate (1 point), with higher scores indicating better bowel cleansing quality. Assessments were conducted independently by three board-certified endoscopists, each with more than 5 years of experience and performing 5 to 7 procedures daily, who were blinded to group allocation. To ensure inter-rater consistency, the evaluators conducted a calibration session beforehand using representative clinical images for each ABPS category.

Patient knowledge of and adherence to bowel preparation medications were measured using instruments adapted from Yu [26]. Knowledge was assessed using a five-item true/false questionnaire evaluating understanding of total dosage, mixing instructions, and ingestion speed; each correct response received 2 points and each incorrect response received 1 point, yielding a score range of 5 to 10. Adherence was measured using a five-item scale with a 4-point Likert scale ranging from 1 (“not at all”) to 4 (“fully”), with a score range of 5 to 20. Although the original instruments by Yu [26] did not include initial validity or reliability data, previous research reported high reliability, with Cronbach’s α values of .92 for knowledge and .80 for adherence. To reflect current practice and specific laxatives, such as Coolprep and Orafang, the items were updated and content validation was performed by a panel of five experts, including three gastroenterologists and two nurses. The resulting CVI was 0.96 for knowledge and 1.00 for adherence. In this study, the Kuder-Richardson Formula 20 (KR-20) was 0.72 for knowledge, and Cronbach’s α was .65 for adherence.

Dietary preparation was assessed using six-item scales adapted from Yu [26]. The dietary knowledge scale measured participants’ understanding of restrictions on seeded fruits, high-fiber vegetables, whole grains, and seaweed for 3 days before colonoscopy, as well as the requirements for a soft diet and appropriate fasting timing on the day before the procedure. Scoring followed the 2/1-point system, with a score range of 6 to 12. Dietary adherence was evaluated using a six-item, 4-point Likert scale, with total scores ranging from 6 to 24. Validity and reliability were confirmed by a five-expert panel, including three gastroenterologists and two nurses, confirmed the alignment of the items with the 2022 Korean Guidelines; therefore, no modifications were required. Choi and Choi [27] reported Cronbach’s α values of .84 for dietary knowledge and .80 for adherence. In this study, the KR-20 for dietary knowledge was 0.67, and Cronbach’s α for adherence was .77.

4) Data collection

To prevent intervention contamination, participants were recruited sequentially, with the control group enrolled first and the experimental group enrolled afterward. After Institutional Review Board (IRB) approval and administrative permission from the nursing department and endoscopy unit were obtained, the first author screened eligible patients using the colonoscopy appointment list in the electronic health records (EHRs), according to the inclusion and exclusion criteria, and consecutively approached eligible outpatients. Eligible patients were approached at the time of colonoscopy scheduling or before the procedure, received an explanation of the study, and provided written informed consent before enrollment. Group allocation was determined by recruitment period rather than randomization, with the control group recruited from April to May 2024 and the experimental group recruited from June to July 2024. At scheduling, both groups received the hospital’s standard printed bowel preparation leaflet once in person from a pharmacist at Chonnam National University Hospital. The leaflet included dietary precautions, foods to avoid, instructions on the timing and method of the prescribed bowel preparation agent, and key precautions regarding medication use, with no differences according to colonoscopy appointment time.

All data were collected by the first author, who screened eligibility, reviewed EHRs using a structured checklist, and distributed and collected the self-administered questionnaires. During April–May 2024, the control group received only the printed materials and had no additional contacts. No additional intervention components, including videos, SMS reminders, or telephone counseling, were provided to the control group. During June to July 2024, the experimental group received the PTBPP in addition to the same printed materials. This included personalized instructional videos viewed 8 days before colonoscopy, SMS reminders beginning 7 days before colonoscopy, and a standardized telephone consultation conducted 2 days before the procedure by the first author, an experienced endoscopy nurse with at least 10 years of experience in bowel preparation education. The personalized instructional videos comprised seven short modules with a total duration of 2 minutes to 3 minutes 40 seconds, and SMS reminders were delivered 2 to 3 times according to the tailored schedule. The telephone consultation followed a standardized counseling and assessment sheet to confirm adherence and address barriers. All participants completed self-administered questionnaires measuring bowel preparation knowledge and adherence before the procedure. During colonoscopy, a board-certified endoscopist evaluated bowel preparation quality.

5) Ethical considerations

This study was approved by the IRB of Chonnam National University Hospital (No. CNUH-2024-116). All participants were informed that participation was voluntary, that they could withdraw at any time without consequences, and that anonymity and confidentiality would be maintained. Written informed consent was obtained from all participants. As a token of appreciation, participants received a South Korean Won 5,000 gift for participating. All study data will be stored securely for 3 years and then permanently destroyed. This study was prospectively registered with the Clinical Research Information Service, Republic of Korea, a World Health Organization International Clinical Trials Registry Platform Primary Registry (No. KCT0011066).

6) Data analysis

All data were analyzed using IBM SPSS ver. 29 (IBM Corp., Armonk, NY, USA), with the two-tailed significance level set at 5%. Descriptive statistics, including frequencies, percentages, medians, and interquartile ranges, were used to summarize demographic and baseline characteristics. Normality was assessed using the Shapiro-Wilk test. Because the normality assumption was not met, group homogeneity and between-group differences were assessed using the chi-square test for categorical variables and the Mann-Whitney U test for ordinal or continuous variables.

RESULTS

1. Baseline Characteristics and Homogeneity between Groups

Baseline characteristics were comparable between groups (Table 1). The homogeneity test showed no significant between-group differences in baseline characteristics, including age, sex, body mass index, education level, presence of underlying diseases, history of colon cancer, previous abdominal surgery, self-administration of bowel preparation medication, constipation, previous colonoscopy experience, and type of laxative (Table 1).

2. Hypothesis Testing of PTBPP Effects

1) Hypothesis 1 (primary outcome)

Bowel preparation quality was assessed using the ABPS. The experimental group had a significantly higher proportion of “excellent” bowel preparation scores than the control group (95% vs. 5%). In contrast, 85% of participants in the control group were rated as “fair.” The Mann-Whitney U test showed a significant between-group difference (Z = 8.13, $p < .001$, r = 0.91) (Table 2). Thus, hypothesis 1 was supported.

2) Hypothesis 2 (secondary outcomes)

The experimental group demonstrated significantly higher knowledge of and adherence to bowel preparation medications than the control group. Medication-related knowledge was significantly greater in the experimental group than in the control group (Z = 3.54, $p < .001$, r = 0.40) (Table 3). Medication adherence was also significantly higher in the experimental group (Z = 6.50, $p < .001$, r = 0.73). Thus, hypothesis 2 was supported.

3) Hypothesis 3 (secondary outcomes)

The experimental group also demonstrated significantly higher knowledge of and adherence to dietary recommendations than the control group. Knowledge of dietary recommendations was significantly greater in the experimental group than in the control group (Z = 5.28, $p < .001$, r = 0.59). Adherence to dietary recommendations was also significantly higher in the experimental group (Z = 5.32, $p < .001$, r = 0.60). Thus, hypothesis 3 was supported.

DISCUSSION

To strengthen the intervention evaluation, contamination was minimized through sequential recruitment, and assessment bias was reduced through blinded ABPS ratings supported by a prior calibration session. The methodological novelty of this study lies in the development and evaluation of a PTBPP that integrated evidence-based educational strategies, including video-based learning, into a

https://doi.org/10.7475/kjan.2026.0105

Table 1. Baseline Characteristics and Homogeneity between Groups

Variables	Categories	Total (N = 80)	Control group (n = 40)	Experimental group (n = 40)	χ^2 or Z	*p*
		Median (IQR) or n (%)				
Age (year)		59.0 (43.3–69.0)	63.5 (44.3–72.8)	52.5 (42.3–66.0)	–1.29	.197
Sex	Male	44 (55.0)	25 (62.5)	19 (47.5)	1.81	.178
	Female	36 (45.0)	15 (37.5)	21 (52.5)		
Body mass index (kg/m^2)		23.6 (22.2–24.9)	23.5 (21.8–24.6)	24.1 (22.4–25.7)	–1.02	.310
Education (year)		14.5 (9.0–16.0)	14.0 (9.0–16.0)	15.5 (9.8–16.0)	–0.54	.588
No. of underlying diseases	≥ 1	58 (72.5)	31 (77.5)	27 (67.5)	1.00	.317
	None	22 (27.5)	9 (22.5)	13 (32.5)		
Colon cancer	Yes	13 (16.2)	6 (15.0)	7 (17.5)	0.09	.762
	No	67 (83.8)	34 (85.0)	33 (82.5)		
History of abdominal surgery	Yes	35 (43.7)	17 (42.5)	18 (45.0)	0.05	.822
	No	45 (56.3)	23 (57.5)	22 (55.0)		
Self-administering bowel preparation medication	Yes	74 (92.5)	38 (95.0)	36 (90.0)	0.72	.396
	No	6 (7.5)	2 (5.0)	4 (10.0)		
Constipation	Yes	8 (10.0)	5 (12.5)	3 (7.5)	0.56	.456
	No	72 (90.0)	35 (87.5)	37 (92.5)		
Previous colonoscopy experience	Yes	78 (97.5)	39 (97.5)	39 (97.5)	0.00	> .999
	No	2 (2.5)	1 (2.5)	1 (2.5)		
Type of laxative	Coolprep	53 (66.3)	25 (62.5)	28 (70.0)	2.79	.425
	SafePrep	12 (15.0)	8 (20.0)	4 (10.0)		
	Colyte	1 (1.3)	1 (2.5)	0 (0)		
	Orafang	14 (17.5)	6 (15.0)	8 (20.0)		

IQR = interquartile range.

Table 2. Comparison of Bowel Preparation Quality Based on the Aronchick Bowel Preparation Scale between Groups

Variables	Total (N = 80)	Control group (n = 40)	Experimental group (n = 40)	U	Z	*p*	Effect size (r)
	n (%)						
Excellent	40 (50.0)	2 (5.0)	38 (95.0)	45.0	8.13	< .001	0.91
Good	5 (6.3)	3 (7.5)	2 (5.0)				
Fair	34 (42.5)	34 (85.0)	0 (0)				
Poor	1 (1.3)	1 (2.5)	0 (0)				
Inadequate	0 (0)	0 (0)	0 (0)				

Effect size (r) = Z/√N.

Table 3. Comparison of Knowledge and Adherence to Bowel Preparation between Groups

Categories	Score range	Total (N = 80)	Control group (n = 40)	Experimental group (n = 40)	U	Z	*p*	Effect size (r)
		Median (IQR)						
Knowledge of bowel preparation medications	5–10	10.0 (10.0–10.0)	10.0 (9.0–10.0)	10.0 (10.0–10.0)	557.0	3.54	< .001	0.40
Adherence to bowel preparation medications	5–20	19.0 (16.0–20.0)	16.0 (14.0–18.0)	20.0 (19.0–20.0)	145.0	6.50	< .001	0.73
Knowledge of dietary recommendations	6–12	12.0 (11.0–12.0)	11.0 (11.0–12.0)	12.0 (12.0–12.0)	313.0	5.28	< .001	0.59
Adherence to dietary recommendations	6–24	23.0 (21.0–24.0)	22.0 (19.0–23.0)	24.0 (24.0–24.0)	281.5	5.32	< .001	0.60

Effect size (r) = Z/√N; IQR = interquartile range.

personalized intervention framework. Previous meta-analytic findings demonstrated the effectiveness of video-based education for improving bowel preparation, with an effect size of 0.66 compared with conventional education methods [10]. Building on this evidence, this study developed a customized PTBPP that included personalized video content tailored to each patient's prescribed bowel preparation agent and scheduled colonoscopy time. The program was further reinforced through individualized counseling to enhance patient adherence. The effectiveness of this four-phase, patient-tailored, multicomponent approach was confirmed, indicating a large effect [28]. Together, these findings suggest that embedding validated educational modalities within a structured, patient-specific delivery pathway may produce clinically meaningful improvements beyond conventional education.

Several mechanisms may explain why the PTBPP outperformed previously reported personalized education interventions. First, the PTBPP begins with structured risk stratification using clinical and behavioral predictors, including previous inadequate preparation, constipation, comorbidities, medication profile, and anticipated adherence barriers; this enables early identification of high-risk patients and proactive intensification of support. Second, the PTBPP uses multiple delivery modes and repeated reinforcement, including written materials, structured counseling, and reinforcement contacts, to minimize misinterpretation and improve regimen fidelity. This approach is supported by a randomized trial showing that multimodal patient education can improve bowel preparation outcomes compared with usual care [29]. Third, the PTBPP incorporates timely reinforcement contacts, such as telephone-based instructions, aligned with key preparation milestones to reduce common implementation failures, including incomplete intake, timing confusion, and misunderstanding of instructions [24]. Collectively, these components extend beyond information tailoring alone by operationalizing a barrier-responsive, time-sensitive adherence support strategy across the preprocedural timeline.

A key component of this study was the incorporation of multiple personalized intervention methods, including demographic and medical history screening, tailored educational materials, and real-time support. Recent studies of personalized bowel preparation interventions have emphasized the importance of accounting for patient-specific factors, such as age, physical condition, psychological state, and education level, primarily through nurse counseling [18] or SMS reminders [15]. In these studies, the reported effect sizes were an odds ratio of 2.090 (Cohen's d = 0.407, medium effect) for bowel preparation quality and an odds ratio of 2.752 (Cohen's d = 0.674, medium-to-large effect) for adherence to bowel preparation medications [18]. In contrast to these predominantly single-modality approaches, the PTBPP combined risk-informed tailoring with structured, repeated reinforcement across the preparation period, which may have increased implementation fidelity and reduced adherence failures in routine practice. Thus, the present findings support the interpretation that personalization may be most effective when paired with multimodal reinforcement and barrier-responsive support rather than information tailoring alone.

The primary outcome, bowel preparation quality, was assessed using the ABPS, a validated and widely used assessment tool in South Korea [30]. A survey-based study of 1,032 South Korean participants found that 63.6% achieved an "excellent" or "good" ABPS rating [30]. Similarly, a study using personalized telephone-based education reported an "excellent/good" rate of 62% [17]. In contrast, the present study demonstrated superior outcomes, with 95% of participants achieving an "excellent" rating and the remaining 5% classified as "good." These findings support the effectiveness of the PTBPP and indicate its potential to improve bowel preparation quality compared with conventional personalized education approaches.

In this study, the PTBPP significantly improved medication- and diet-related knowledge and adherence, which are key targets of enhanced patient instructions recommended in bowel preparation guidelines [6]. Video-based education has been shown to improve bowel preparation outcomes, supporting the use of tailored educational videos to strengthen patients' understanding of preparation steps [10]. Reinforced education delivered near the time of colonoscopy via telephone or SMS has been effective in improving bowel preparation quality, suggesting that time-aligned reminders may help translate knowledge into adherence [15]. A recent meta-analysis also demonstrated that telephone instructions significantly improve bowel preparation quality, supporting nurse-led telephone consultation as a practical strategy for reinforcing medication and dietary instructions [24]. Multifaceted, person-centered interventions that include active discussion are more likely to improve health literacy and related health behaviors, which may explain the observed gains in knowledge and adherence [31].

Given the effectiveness of the PTBPP, integration into clinical workflows is an important next step [32]. This study used EHRs for risk factor screening, allowing efficient identification of high-risk patients. Future work should integrate the PTBPP into EHR systems to enable automated delivery of tailored video education and personalized text messages, thereby reducing the need for manual intervention. Although nurse expertise is essential to the success of personalized interventions, the limited availability of highly skilled healthcare professionals may challenge the scalability of individualized interventions. With advances in artificial intelligence (AI), future research could develop AI-enabled decision support systems that use EHR-derived factors to predict patients at high risk of inadequate bowel preparation and support preprocedural detection or triage to trigger timely rescue instructions [33]. Such systems may automate routine guidance and reminders while allowing nurses to focus on complex counseling and safety checks [34].

This study had several limitations. First, because of the nonequivalent control group posttest-only design, baseline knowledge and adherence were not statistically compared. This design was chosen because assessing knowledge of specific laxatives and dietary protocols before education is provided is not practically feasible in clinical settings. In addition, this design eliminated potential pretest sensitization. Although direct baseline measures were not available, the two groups were homogeneous in major clinical and demographic variables. Second, although the primary outcome, bowel preparation quality, was assessed using the ABPS by three endoscopy specialists, inter-rater reliability among the three evaluators was not formally validated. To mitigate this limitation, the evaluators conducted a calibration session beforehand using representative clinical images. The ABPS has been established as a validated tool in previous research [25], and the expertise of the endoscopists, each with more than 5 years of clinical experience, likely strengthened the validity of the primary outcome assessment. Third, medication- and diet-related knowledge and adherence were measured using self-administered instruments. Although content validity was assessed and internal consistency was examined, further psychometric validation, such as construct validity, criterion validity, and test–retest reliability, was not performed. Fourth, although this study screened multiple risk factors for inadequate bowel preparation and incorporated them into a structured checklist, health literacy was not included in the screening process. Given that health literacy is an important determinant of the effectiveness of personalized interventions [31], future research should develop comprehensive screening checklists that include literacy assessments to optimize the personalization of educational interventions. Fifth, the intervention effect size may have been overestimated because older adults with limited smartphone proficiency were excluded. Because the intervention required participants to access personalized videos and text messages, eight individuals who had difficulty using mobile phones were excluded. In addition, another eight participants dropped out before completing the study, potentially because of challenges accessing personalized digital content. Therefore, future research should develop programs based solely on telephone counseling for individuals with low digital literacy to ensure more inclusive intervention strategies.

CONCLUSION

This study demonstrated that the PTBPP, which integrated personalized education through videos, SMS reminders, and nurse counseling, significantly improved bowel preparation quality, medication adherence, and dietary adherence compared with conventional paper-based education. Future research should focus on automating the PTBPP within EHR systems and exploring alternative delivery methods, such as telephone-based counseling, to address digital literacy barriers. These findings highlight the need for scalable, AI-assisted personalized interventions to optimize patient education and bowel preparation outcomes in clinical practice.

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CONFLICTS OF INTEREST

The authors declared no conflict of interest.

AUTHORSHIP

Study conception and design acquisition - SHJ and SHM; data collection - SHJ; data analysis - SHJ; the interpretation of the data - SHJ and SHM; discussion and conclusions - SHJ and SHM; drafting and critical revision of the manuscript - SHJ and SHM.

FUNDING

This work was conducted with the support of the 2024 Health Fellowship Foundation.

ACKNOWLEDGEMENT

None.

DATA AVAILABILITY STATEMENT

The data can be obtained from the corresponding authors.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found via https://doi.org/10.7475/kjan.2026.0105.

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KJAN
Korean Journal of
Adult Nursing

Instructions for Authors

Korean Journal of Adult Nursing
Enacted in June 1994, most recently revised in May 2025 and, applied from Vol. 37, No. 2 (May 2025).

Table of Contents

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.

2. Authorship

KJAN follows the recommendations for authorship set out by the ICMJE Authorship guidelines (http://www.icmje.org/icmje-recommendations.pdf). Authorship is attributed only to individuals who have directly participated and made significant contributions to the creation of the manuscript. Authorship should be based upon all four of the following criteria: 1) substantial contribution to the concept or design of the work, or the acquisition or analysis and interpretation of data; 2) drafting the work or revising it critically for important intellectual content; 3) final approval of the version submitted for publication; 4) accountability for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All other contributors not listed as authors should be mentioned in the acknowledgements section.

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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This journal encourages and enables authors to share data that supports the research publication, where appropriate, and to interlink the data with other published articles. Research data refers to the results of observations or experiments that validate the research findings. To facilitate reproducibility and data reuse, this journal encourages authors to share their software, codes, models, algorithms, protocols, methods, and other useful materials related to the project. Data generated through the participation of subjects and the public should be put to maximum use by the research community and, whenever possible, translated to deliver patient benefits. Data sharing benefits numerous research-related activities: reproducing analyses, testing secondary hypotheses, developing and evaluating novel statistical methods, teaching, aiding the design of future trials and meta-analyses, and helping to prevent error, fraud, and selective reporting. To promote more transparent and reproducible research, we ask authors to submit a Data Availability Statement in the manuscript to help readers understand how they can access the data, code, and other resources that support the research findings.

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.
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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.

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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.

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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 0.001 (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

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