

ORIGINAL ARTICLES

- A Preliminary Study of Motivational Interviewing Training Using a Large Language Model (ChatGPT): Effects on Empathy and Motivational Interviewing Confidence among Social Work Students
Ho Yeob KANG, Sohyun WOO, and Hee Jung KIM
- Psychosocial Factors Associated with Smoking Cessation Stage among Korean Female Call Center Workers
Sunjoo BOO
- Occupational Stress, Work-Life Balance, and Intention to Stay among Nurses during the COVID-19 Pandemic: A Cross-Sectional Study
Kyoung Hye MIN, Seon Hee KIM, Young KO, and Myung Jin JANG
- Seasonal Trends of Chronic Obstructive Pulmonary Disease and Asthma with a Meteorological Analysis in Korea: Using the National Health Insurance Service-Senior Database 2.0
Tae-hoon LEE, Hayoung SHIM, and Belong CHO
- Association of the Arachidonic Acid-to-Eicosapentaenoic Acid Ratio with Metabolic Dysfunction-Associated Steatotic Liver Disease and the Fibrosis-4 Index in Korean Adult Health Check-up Examinees: A Single-Center Cross-Sectional Study
Sung-Jae JANG and Bo-Kyung SHINE
- Knowledge, Attitudes, and Practices Regarding Antenatal Care among Women in High-Risk Areas of El Salvador: A Baseline Survey for Future Program Evaluation
Yong Hyun KIM, Elnor CRESPIN, and Byung Wook YOO
- Prediction Models for Unplanned Removal of Peripherally Inserted Central Catheters and Their Risk Factors: A Narrative Review
Seon Min LEE and Jeong Yun PARK
- Factors Associated with Current E-Cigarettes Use of Female Workers: Using the 2023 Community Health Survey
Eungyeong KIM



Korean Society for Health Promotion and
Disease Prevention

VOL. 26 / NO. 3 / September 2026

Aims and Scope

The *Korean Journal of Health Promotion (KJHP)* is an open access, multidisciplinary journal dedicated to publishing high-quality research in various areas of the medical, nursing, nutritional, physical educational, epidemiological, and public health sciences associated with health promotion and disease prevention. *KJHP*, which has been published continuously since 2001, is an official journal of the Korean Society for Health Promotion and Disease Prevention.

The aim of the *KJHP* is to advance and disseminate new knowledge and scientific information in all the areas associated with health promotion and disease prevention. *KJHP* publishes original articles, narrative reviews, systematic reviews and meta-analyses, letters to the editor, and perspectives in English.

Abbreviation

The correct abbreviation for abstracting and indexing purposes is *Korean J Health Promot.*

This journal is financially supported by the Korean Federation of Science and Technology Societies (KOFST) Grant funded by the Korean Government.

Open Access

Korean Journal of Health Promotion is an open access journal distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article processing charge

No review fees are charged for all the submitted articles. Article processing charges are required for publication in the *KJHP*. Publication fees for all the accepted original or review articles are 300,000 Korean Won (250 US dollars). Additionally, if the article exceeds 6 pages of the journal, additional fees (50,000 Korean Won or 40 US dollars per extra page) will be charged.

Publisher: President, Sung SUNWOO, MD, MPH, PhD
Department of Family Medicine, Asan Medical Center
Korean Society for Health Promotion and Disease Prevention

Editor-in-Chief: Seung-Kwon MYUNG, MD, PhD
Department of Family Medicine, National Cancer Center
Department of Public Health & AI, National Cancer Center Graduate School of Cancer Science and Policy

Editorial Office

Korean Society for Health Promotion and Disease Prevention
Department of Family Medicine, Asan Medical Center, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea
Tel: +82-2-3010-3820 Fax: +82-2-3010-3815 E-mail: kshdpd@amc.seoul.kr

Printing Office

M2PI
#805, 26 Sangwon 1-gil, Seongdong-gu, Seoul 04779, Korea
Tel: +82-2-6966-4930 Fax: +82-2-6966-4945 E-mail: support@m2-pi.com

Editors

Editor-in-Chief

Seung-Kwon MYUNG, MD, PhD

Department of Family Medicine, National Cancer Center, Korea

Department of Public Health & AI, National Cancer Center Graduate School of Cancer Science and Policy, Korea

Associate (Section) Editors

Medicine

Yoo-Soo CHANG, MD, PhD

Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Korea

Yoon-Jung CHOI, MD, PhD

Department of Family Medicine, National Cancer Center, Korea, Department of Cancer Control and Population Health, National Cancer Center Graduate School of Cancer Science and Policy, Korea

Hong-Bae KIM, MD, PhD

Department of Family Medicine, Myongji Hospital, Hanyang University College of Medicine, Korea

Seung-Won OH, MD, PhD

Department of Family Medicine, Seoul National University College of Medicine, Korea

Nursing

Sunjoo BOO, PhD

College of Nursing-Research Institute of Nursing Science, Ajou University, Suwon, Korea

Eunjoo KIM, PhD

Jeju National University College of Nursing, Korea

Young KO, PhD

College of Nursing, Gachon University, Korea

Nutrition

Jayong CHUNG, PhD

Department of Food and Nutrition, Kyung Hee University, Korea

Sim Yeol LEE, PhD

Food and Nutrition Dongguk University, Korea

Kinesiology

Jae-Jong BYUN, PhD

Department of sports health and rehabilitation, Woosong University, Korea

Yonghyun BYUN, PhD

Graduate School of Sports Science, Dankook University, Korea

Moonhyon HWANG, PhD

Division of Health and Kinesiology, Incheon National University, Korea

SungJin YOON, PhD

Department of Physical Education, College of Education, Korea University, Korea

Former Editor-in-Chief

Byung-Sung KIM, MD, PhD

Department of Family Medicine, Kyung Hee University School of Medicine, Korea

Moo-Song LEE, MD, PhD

Department of Preventive Medicine, University of Ulsan College of Medicine, Korea

Sang Ho YOO, MD, PhD

Department of Medical Humanities and Ethics, Hanyang University College of Medicine, Korea

Editorial Board Members

Medicine

Mostafa ALIKIHANI, MA

Department of Psychology, Kermanshah University of Medical Sciences, Iran

Karen M Flegg, MBBS, MIntPH

ANU Medical School, Australian National University, Australia

Hee-Taik KANG, MD, PhD

Department of Family Medicine, Chungbuk National University College of Medicine, Korea

Chul-Min KIM, MD, PhD

Department of Family Medicine, Catholic University of Korea College of Medicine, Korea

Hwa Jung KIM, MD, PhD

Department of Clinical Epidemiology and Biostatistics, University of Ulsan College of Medicine, Korea

Hyeon Ju KIM, MD, PhD

Department of Family Medicine, Jeju National University College of Medicine, Korea

Youn Pyo KIM, MD, PhD

Department of Family Medicine, Chonnam National University Medical School, Korea

Tesshu KUSABA, MD, PhD

Department of Family Medicine, The Hokkaido Centre for Family Medicine, Japan

Joongyub LEE, MD, PhD

Medical Research Collaborating Center, Seoul National University Hospital, Korea

Kayoung LEE, MD, PhD

Department of Family Medicine, Inje University College of Medicine, Korea

Joo-Sung PARK, MD, PhD

Department of Family Medicine, Dong-A University College of Medicine, Korea

Salvador PEIRÓ, MD, PhD

Health Services Research and Pharmacoepidemiology Unit, Foundation for the Promotion of Health and Biomedical Research of the Valencian Community (FISABIO), Spain

Joung Sik SON, MD, PhD

Department of Family Medicine, Seoul National University Hospital, Korea

Sang-Wook SONG, MD, PhD

Department of Family Medicine, Catholic University of Korea College of Medicine, Korea

Eunju SUNG, MD, PhD

Department of Family Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Korea

Nursing

Eun Suk CHOI, PhD

College of Nursing, Kyungpook National University, Korea

Jeong Hee KANG, PhD

College of Nursing, Jeonbuk National University, Korea

Jeong Hee KIM, PhD

Jeju National University College of Nursing, Korea

Kusum KUMARI, PhD

College of Nursing, All India Institute of Medical Sciences, India

Editors

Nutrition

Jin Ah CHO, PhD

Department of Food and Nutrition, Chungnam National University, Korea

Sung-Nim HAN, PhD

Department of Food and Nutrition, Seoul National University College of Human Ecology, Korea

Jihye KIM, PhD

Department of Medical Nutrition, Kyung Hee University, Korea

Eunmi PARK, PhD

Department of Food and Nutrition, Hannam University, Korea

YiKyung PARK, ScD

Department of Public Health Sciences Washington University in St. Louis, MO, USA

YoonJu SONG, PhD

Department of Food and Nutrition, Catholic University of Korea, Korea

Kinesiology

Boo Geun HWANG, PhD

Department of Sport Rehabilitation Tongmyong, Woosong University, Korea

Jin-Seok Lee, PhD

Department of physical Education, Daegu National University of Education, Korea

Junga LEE, PhD

The Graduate School of Physical Education, Kyung Hee University, Korea

Jae Sung PARK, PhD

Kongju National University Physical Education, Korea

Ethics Editor

Jeong Yun PARK, PhD

Department of Nursing, University of Ulsan, Korea

Statistics Editor

Sung-Cheol YOON, PhD

Department of Digital Medicine, University of Ulsan, Korea

Editorial Staff

Young-Joo KANG

Korean Society for Health Promotion and Disease Prevention, Korea

Manuscript Editor

Hyun Jung KWON

Freelancer, Korea

Website and JATS XML file producer

Hyun Kyung LEE

M2PI, Korea

Contents

VOL. 26 / NO. 3 / September 2026

ORIGINAL ARTICLES

- 83** A Preliminary Study of Motivational Interviewing Training Using a Large Language Model (ChatGPT): Effects on Empathy and Motivational Interviewing Confidence among Social Work Students
Ho Yeob KANG, Sohyun WOO, and Hee Jung KIM
- 94** Psychosocial Factors Associated with Smoking Cessation Stage among Korean Female Call Center Workers
Sunjoo BOO
- 102** Occupational Stress, Work-Life Balance, and Intention to Stay among Nurses during the COVID-19 Pandemic: A Cross-Sectional Study
Kyoung Hye MIN, Seon Hee KIM, Young KO, and Myung Jin JANG
- 110** Seasonal Trends of Chronic Obstructive Pulmonary Disease and Asthma with a Meteorological Analysis in Korea: Using the National Health Insurance Service–Senior Database 2.0
Taehoon LEE, Hayoung SHIM, and Belong CHO
- 123** Association of the Arachidonic Acid-to-Eicosapentaenoic Acid Ratio with Metabolic Dysfunction-Associated Steatotic Liver Disease and the Fibrosis-4 Index in Korean Adult Health Check-up Examinees: A Single-Center Cross-Sectional Study
Sung-Jae JANG and Bo-Kyung SHINE
- 133** Knowledge, Attitudes, and Practices Regarding Antenatal Care among Women in High-Risk Areas of El Salvador: A Baseline Survey for Future Program Evaluation
Yong Hyun KIM, Elnor CRESPIAN, and Byung Wook YOO
- 145** Prediction Models for Unplanned Removal of Peripherally Inserted Central Catheters and Their Risk Factors: A Narrative Review
Seon Min LEE and Jeong Yun PARK
- 156** Factors Associated with Current E-Cigarettes Use of Female Workers: Using the 2023 Community Health Survey
Eungyeong KIM

A Preliminary Study of Motivational Interviewing Training Using a Large Language Model (ChatGPT): Effects on Empathy and Motivational Interviewing Confidence among Social Work Students

Ho Yeob KANG, PhD¹, Sohyun WOO, PhD², and Hee Jung KIM, PhD³

¹Department of Social Welfare, Dong-A University of Health, Yeongam, Korea

²The Research Institute of Nursing Science, College of Nursing, Seoul National University, Seoul, Korea

³Department of Nursing, Gachon University, Incheon, Korea

ABSTRACT

Background: Motivational interviewing (MI) requires repeated practice, individualized feedback, and ongoing coaching that short-term group education cannot sufficiently provide. Large language models (LLMs) such as ChatGPT may offer realistic conversational simulation and immediate feedback. This pilot study examined whether an LLM (ChatGPT)-integrated MI training program improves empathy and MI Confidence among social work students.

Methods: A one-group repeated measures quasi-experimental design was applied to 15 undergraduate social welfare students. The four-session program used ChatGPT (GPT-5.5) as a virtual client for open-ended questions, affirmations, reflective listening, and summaries (OARS) practice with automated Motivational Interviewing Treatment Integrity-based feedback. Empathy, MI Skill Confidence, and Global Interviewing Confidence were measured at pretest, posttest, and 4-week follow-up, and analyzed using Friedman and Wilcoxon signed-rank tests. Qualitative content analysis of participants' experiences was also conducted.

Results: Empathy improved significantly across time points ($\chi^2=6.037$, $P=0.049$), increasing from pretest to posttest ($P=0.014$) and remaining higher at follow-up ($P=0.037$). MI Skill Confidence showed an upward trend without statistical significance ($\chi^2=2.561$, $P=0.278$). Global Interviewing Confidence changed significantly ($\chi^2=6.682$, $P=0.035$), being higher at follow-up than pretest ($P=0.021$). Qualitative analysis yielded four themes: realistic simulation, immediate feedback, skill mastery through repeated practice, and requests for enhanced realism.

Conclusions: An LLM (ChatGPT)-integrated MI training program may improve empathy and overall interviewing confidence and function as an effective auxiliary tool complementing traditional MI education. LLMs can support learners' repeated practice and immediate feedback.

Keywords: Motivational interviewing, Empathy, Artificial intelligence, Self efficacy, Simulation training

Received: July 14, 2026; Revised: July 31, 2026; Accepted: August 10, 2026

Corresponding author: Hee Jung KIM, PhD

Department of Nursing, Gachon University, 191 Hambangmoe-ro, Yeonsu-gu, Incheon 21936, Korea

Tel: +82-32-820-4224 Fax: +82-31-750-8859 E-mail: illine@paran.com

INTRODUCTION

Motivational interviewing (MI), developed by Miller and Rollnick [1], is a client-centered, collaborative, evidence-based approach that helps clients explore and strengthen their own motivation for change. Over the past four decades, MI has demonstrated effectiveness across diverse fields, including addiction, chronic disease management, mental health, and social welfare, and is widely used in settings requiring health behavior change.

In Korea, MI education and training have been actively conducted in the medical, counseling, and social welfare fields. In social work, where empathic communication forms the foundation of professional relationships, prior studies have reported that MI training improves practitioners' empathy and communication self-efficacy [2,3]. On the basis of these effects, MI has been used as a major practice model in social work practice skills [3,4].

MI training has been delivered through various methods, including lecture, role play and video feedback, and reliable tools such as the Motivational Interviewing Treatment Integrity (MITI) 4.2.1 [5] have been developed to evaluate outcomes. However, because MI requires not merely the acquisition of knowledge but strategic communication competence encompassing advanced relationship-building skills and reflective techniques, short-term education alone makes it difficult to maintain proficiency [3,6]. Moreover, for MI training to be sufficiently translated into and sustained as learner competence, repeated practice, individualized feedback, and ongoing coaching are essential [3,7]. Yet practical constraints such as cost, time, and limited expert resources often confine training to short-term group education [6,8], and new training environments that can complement these limitations are needed.

Recent advances in artificial intelligence (AI) have been changing education and training methods across various professional fields. Generative AI in particular has drawn attention as a tool that supports repeated practice and individualized learning by implementing interactive learning environment and automated feedback [8,9]. Among these, large language models (LLMs) such as ChatGPT can provide realistic conversational simulations giving them potential well suited to communication-based training. LLMs can implement diverse clinical scenarios and provide immediate interaction, thereby creating an environment for repeated practice without the continuous involvement of standardized patients or instructors [10].

Studies on counseling and communication training using AI and LLMs have recently been reported. Some studies have suggested that AI-based training using virtual patients can positively affect the improvement of empathy and patient-centered communication competence [11,12]. In addition, Zhu et al. [13] reported that users with prior ChatGPT experience differed from first-time users in their utterance patterns, use of strategic questions, and frequency of change talk. Thus, prior LLM experience may influence MI-based interactions.

Despite this potential, the clinical suitability of LLMs requires careful examination. Basar et al. [14] analyzed the quality of reflections generated by an LLM and found that the ability to perform deep inference about emotion or to strategically promote change talk was limited. This limitation suggests that LLMs may serve as supportive tools for beginning learners' repeated practice rather than as replacements for skilled counselors [15]. Meyer [16] likewise confirmed that MI principles can be reflected in an LLM to a limited extent but noted that empirical verification of its actual educational effects has yet to be established.

However, few studies have examined how LLM-based MI education affects core outcome variables such as learners' MI Confidence and empathy competence. This study therefore sought to verify whether an LLM (ChatGPT)-integrated MI training program improves trainees' MI Confidence and empathy competence, thereby providing evidence on whether LLM-based training can complement traditional MI education as a supportive tool.

METHODS

Study design

This study was a pilot study to explore the effects of an MI training program using an LLM (ChatGPT) among undergraduate social work students, applying a one-group repeated-measures quasi-experimental design.

Participants

Participants were recruited from undergraduate students enrolled in the Department of Social Welfare at D University, located in J Province, who participated in an extracurricular program. To ensure homogeneity of the participants, eligibility was limited to students with no prior educational experience related to MI or to generative AI. Recruitment was conducted through departmental bulletin-board announcements and promotion; after being informed of the study's purpose, students who vol-

untarily expressed an intention to participate were selected.

G*Power 3.1.9.4 was used to determine the sample size. Based on a repeated-measures analysis of variance (ANOVA) with an effect size (f) of 0.25, a significance level (α) of 0.05, a power ($1-\beta$) of 0.80, and three measurement points (pretest, posttest, and 4-week follow-up), a minimum of 28 participants was required. Considering possible attrition, recruitment targeted 30 participants; however, only 17 were recruited because participation was voluntary. After excluding 2 incomplete responses, 15 participants were included in the final analysis.

Large language model (ChatGPT)-integrated motivational interviewing training program

The program was based on the MI-based communication training program of Kang et al. [3], and the session structure was organized into a total of four sessions based on Kang and Lim [2]. The goals of the program were to improve empathy competence and to enhance MI Confidence, and the educational content was organized around the MI spirit and the core skills (open-ended questions, affirmations, reflective listening, and summaries, OARS) (Table 1).

Content validity of the program was reviewed by two MI experts, and the Content Validity Index (CVI) was calculated using a 5-point Likert scale. Evaluated according to the criterion of Fehring [17] ($CVI \geq 0.80$), both the program content and the session structure showed a CVI of 1.00, confirming content validity.

Each session consisted of a lecture (20 minutes), a demonstration (10 minutes), simulation practice (20 minutes), and

instructor feedback (10 minutes). Throughout all sessions, ChatGPT (GPT-5.5) served as a virtual client for practicing OARS, responding in real time to participants' utterances and providing automated feedback based on the MITI 4.2.1 [5]. The practice used a single case of "a client who wants to quit smoking but is experiencing difficulty" (Appendix 1). Applying the same case across all sessions reduced the time needed to adapt to it and allowed OARS to be practiced step by step within the limited training time (Table 2). Practice was conducted individually using participants' personal smartphones, tablets, or desktop computers.

Data collection and intervention

To examine the program's effects, empathy competence and MI Confidence were measured at three time points. The pretest was conducted before the program began, the posttest immediately after it ended, and the follow-up 4 weeks later. Qualitative data were also collected through open-ended questions to explore participants' learning experiences with the LLM.

Measurements

Empathy

Empathy was measured using the adult empathy scale developed by Kim and Kim [18]. The scale consists of 32 items rated on a 5-point Likert scale (1="strongly disagree" to 5="strongly agree"). The total score ranges from 32 to 160, with higher scores indicating higher levels of empathy. The reliability (Cron-

Table 1. LLM (ChatGPT)-integrated MI training program

Session	Time (min)	Topic	Learning objectives	Methods
1	60	MI foundations	MI foundations	Understand MI spirit and principles
			Ambivalence & change talk	Identify and respond to change talk (practice double-sided reflection)
2	60	MI skills 1	Open-ended questions	Practice open-ended questions
			Affirmation	Practice Affirmation
3	60	MI skills 2	Simple reflection	Practice simple reflections
			Complex reflection	Practice complex reflections
4	60	Integration	Summarizing	Practice summarizing
			Integration and role-play practice	Conduct a brief MI conversation

Each session consisted of a 20-minute lecture, a 10-minute demonstration, a 20-minute ChatGPT-based simulation practice, and a 10-minute wrap-up and feedback.

LLM, large language model; MI, motivational interviewing.

Table 2. ChatGPT-based simulation practices used in the MI training program

Session	MI skill	Simulation task	ChatGPT role
1	Change talk	Identifying and responding to change talk	Acts as a client who wants to quit smoking but is experiencing difficulties
2	Open-ended questions	Open-ended question practice	Responds naturally to open-ended questions while expressing change talk
	Affirmation	Affirmation practice	Responds to affirmations while discussing smoking cessation experiences
3	Simple reflection	Simple reflection practice	Responds to simple reflections and maintains the conversation
	Complex reflection	Complex reflections practice	Responds to complex reflections and elaborates on change talk
4	Summarizing	Summarizing practice	Provides extended responses for summarizing practice
	Integration	MI role-play practice	Acts as a smoking cessation client and provides overall feedback on MI skills

All practice sessions employed a standardized smoking-cessation scenario involving a client experiencing difficulty quitting smoking. Participants practiced each MI skill five times with ChatGPT and subsequently received automated feedback based on the Motivational Interviewing Treatment Integrity (MITI) coding framework. The following is an example of the prompts used in the practice sessions: [Prompt Example] Enter the prompts below to assume the role of the counselor and conduct five simple reflections to facilitate a conversation about change with the client (Chat GPT). Chat [GPT Instructions] "Assume you are a client who wants to quit smoking but is struggling, and answer my open-ended questions naturally. After conducting the five simple reflections, provide feedback based on the Motivational enhancement counseling MITI coding system regarding whether the reflections successfully led to a conversation about change."

MI, motivational interviewing.

bach’s α) at the time of scale development was 0.93, and in this study it was 0.94.

Motivational interviewing Confidence

(1) Motivational interviewing Skill Confidence
Confidence in performing the core MI skills was measured using the Motivational Interviewing Confidence Survey developed by Larson and Martin [19]. The original instrument consists of 24 items, each rated on an 11-point Likert scale ranging from 0 (“strongly disagree”) to 10 (“strongly agree”). The total score of the original scale ranges from 0 to 240, with higher scores indicating greater confidence in MI performance. In this study, considering alignment with the program goals, 10 items directly related to the core skills (OARS) were selected. Accordingly, the total score in this study ranged from 0 to 100, with higher scores indicating greater MI Skill Confidence. The reliability in this study was 0.95. To ensure the content validity of the selected items, they were reviewed by two MI experts.

(2) Global Interviewing Confidence
Overall confidence in conducting interviews was assessed using a single-item scale based on a Numerical Rating Scale. The item consisted of the single question, “Overall, how confident are you in conducting an interview with a client?” rated from 1 (“not at all confident”) to 10 (“very confident”). Higher scores indicate greater overall confidence in conducting interviews.

Qualitative data collection

To explore learning experiences and perceptions, applicability,

and areas for improvement that are difficult to explain with quantitative results alone, qualitative data on participants’ experiences using the LLM (ChatGPT) were collected after the program ended. The questions were, “How was it for you to use the LLM (ChatGPT) in this MI training?” and “What were the strengths and limitations (areas for improvement) of using the LLM (ChatGPT) in this MI training?” To clarify the meaning of the responses and to explore experiences in greater depth, additional individual interviews were conducted with 5 participants. The collected data were integrated and used for qualitative content analysis [20].

Data analysis

Quantitative analysis

Quantitative data were analyzed using IBM SPSS Statistics 24.0 (IBM Corp.). The general characteristics of the participants were summarized using frequencies, percentages, means, and standard deviations (SDs). Program effects were evaluated by analyzing changes in empathy competence and MI Confidence measured at the pretest, posttest, and 4-week follow-up. Because the normality assumption was not satisfied, nonparametric tests were applied. Changes across the three time points were analyzed using the Friedman test, and when significant results were identified, the Wilcoxon Signed-Rank Test was conducted as a post hoc analysis. The statistical significance level was set at $P<0.05$.

Qualitative analysis

The collected qualitative data were analyzed using the qualitative content analysis method [20]. During the analysis, two researchers

independently and repeatedly read the participants' responses, derived meaning units, and conducted first-round coding. Subsequently, through mutual comparison and validity review between the researchers, similar content was categorized and refined, and ultimately four themes and five subthemes were derived.

To ensure the trustworthiness of the analysis, four criteria proposed by Guba [21] were considered: credibility, dependability, transferability, and confirmability. Differences in interpretation between the researchers were reconciled through discussion to reach consensus. The analysis and categorization procedures were systematically recorded using Microsoft Excel to ensure consistency, and the participants, study procedures, and data analysis process were described in detail to enhance transferability.

Ethical consideration

This study was conducted after receiving approval from the Institutional Review Board of Gachon University (approval no. 1044396-202603-HR-036-001). After the study's purpose and procedures were explained, voluntary written consent was obtained from participants, who were informed that they could withdraw from the study at any time without disadvantage. The collected data were anonymized and used only for research purposes.

RESULTS

General characteristics of participants

The general characteristics of the participants are presented in Table 3. There were 15 participants in total: 14 females (93.3%) and 1 male (6.7%). Regarding age, those in their 40s were most common at 8 participants (53.3%), followed by those aged 50 or older at 5 (33.3%) and those in their 30s at 2 (13.3%). The average daily use of generative AI was 10 minutes or more for 8 participants (53.3%) and 5 minutes or less for 7 (46.7%). For familiarity with AI, "moderate" and "familiar" were each most common at 6 participants (40.0%), followed by "very familiar" at 2 (13.3%) and "not at all familiar" at 1 (6.7%).

Changes in outcome variables across measurement points

Empathy

A Friedman test conducted to analyze changes in empathy competence across time points showed a statistically significant difference according to measurement point ($\chi^2=6.037$, $P=0.049$) (Table 4). A Wilcoxon signed-rank test conducted as a post hoc analysis showed that empathy competence significantly increased from pretest (mean $\pm$ SD, 133.0 $\pm$ 11.88) to posttest (141.6 $\pm$ 15.02) ($z=-2.449$, $P=0.014$), and the level at the 4-week follow-up (140.4 $\pm$ 14.82) also remained significantly higher than at pretest ($z=-2.080$, $P=0.037$).

Motivational interviewing Confidence

(1) Motivational interviewing Skill Confidence

A Friedman test conducted to analyze changes in MI Skill Confidence across time points showed no statistically significant difference according to measurement point ($\chi^2=2.561$, $P=0.278$). The mean scores tended to increase from 69.60 $\pm$ 12.34 at pretest to 78.26 $\pm$ 9.84 at posttest and 74.93 $\pm$ 8.16 at follow-up, but the difference was not statistically significant (Table 5).

Table 3. General characteristics of participants (n=15)

Characteristics	Categories	Number (%)
Sex	Male	1 (6.7)
	Female	14 (93.3)
Age (yr)	30–39	2 (13.3)
	40–49	8 (53.3)
	≥ 50	5 (33.3)
Daily use of generative AI (ChatGPT) (min)	≤ 5	7 (46.7)
	≥ 10	8 (53.3)
For familiarity with AI (ChatGPT)	Not at all familiar	1 (6.7)
	Moderate	6 (40.0)
	Familiar	6 (40.0)
	Very familiar	2 (13.3)

AI, artificial intelligence.

Table 4. Changes in empathy across measurement points (n=15)

Variable	Statistics	Pre	Post	Follow-up	χ^2	P	Post-hoc (Wilcoxon signed-rank test)
Empathy	Mean $\pm$ SD	133.0 $\pm$ 11.88	141.6 $\pm$ 15.02	140.4 $\pm$ 14.82	6.037	0.049*	Pre-Post: $z=-2.449$, $P=0.014^*$
	Median (range)	133 (109–153)	141 (117–160)	144 (117–160)			Pre-Follow-up: $z=-2.080$, $P=0.037^*$ Post-Follow-up: $z=-0.525$, $P=0.600$

Follow-up assessment was conducted 4 weeks after program completion. Friedman test was used to examine overall differences across three measurement points, followed by Wilcoxon signed-rank tests for pairwise comparisons.

Post, posttest; Pre, pretest; SD, standard deviation.

* $P<0.05$.

Table 5. Changes in MI Confidence across measurement points (n=15)

Variable	Statistics	Pre	Post	Follow-up	χ^2	P	Post-hoc (Wilcoxon signed-rank test)
MI Skill Confidence	Mean±SD	69.60±12.34	78.26±9.84	74.93±8.16	2.561	0.278	
	Median (range)	72.0 (40–86)	79.0 (59–100)	74.0 (63–88)			
Global Interview Confidence	Mean±SD	6.20±1.69	7.13±1.59	7.33±1.11	6.682	0.035*	Pre-Post: z=-1.602, P=0.109 Pre-Follow-up: z=-2.312, P=0.021* Post-Follow-up: z=-0.493, P=0.622
	Median (range)	7.0 (3–8)	7.0 (3–10)	7.0 (5–9)			

MI Skill Confidence refers to confidence in performing OARS-related motivational interviewing skills. Global Interviewing Confidence refers to overall confidence in conducting client interviews. Follow-up assessment was conducted 4 weeks after program completion. Friedman test was used to examine overall differences across three measurement points. Wilcoxon signed-rank tests were conducted as post-hoc analyses when significant overall differences were identified.

MI, motivational interviewing; OARS, open-ended questions, affirmations, reflective listening, and summaries; Post, posttest; Pre, pretest; SD, standard deviation.

*P<0.05.

Table 6. Qualitative findings on the use of ChatGPT in MI training

Theme	Subtheme
Realistic simulation experience	Realistic interaction with a virtual client
Learning facilitated by immediate feedback	Real-time correction and summarization of the core skills (OARS)
Skill development through repeated practice	Repeated practice in a low-pressure setting
Requests for enhanced realism	Formulaic and limited response patterns Requests for responses with nonverbal cues

MI, motivational interviewing; OARS, open-ended questions, affirmations, reflective listening, and summaries.

(2) Global Interviewing Confidence

A Friedman test conducted to analyze changes in Global Interviewing Confidence across time points showed a statistically significant difference according to measurement point ($\chi^2=6.682$, $P=0.035$). The mean scores increased from 6.20 ± 1.69 at pretest to 7.13 ± 1.59 at posttest and 7.33 ± 1.11 at follow-up. Post hoc analysis showed no significant differences for the pretest–posttest ($z=-1.602$, $P=0.109$) or posttest–follow-up ($z=-0.493$, $P=0.622$) comparisons, whereas the difference between pretest and the 4-week follow-up was statistically significant ($z=-2.312$, $P=0.021$) (Table 5).

Qualitative findings on the use of ChatGPT in motivational interviewing training

Analysis of the qualitative data yielded four themes and five subthemes (Table 6).

(1) Realistic simulation experience

Participants reported that training using ChatGPT felt like interacting with an actual client and that its immediate responses to their questions made the practice feel like a real counseling session. They also reported becoming more immersed in this process.

“Because a response actually came (from ChatGPT), I could

think about how to ask questions so that the client could move in an appropriate direction.” (Participant 2)

“The more I did it, the more immersed I became. I really felt like a counselor, and I could genuinely sense what a counselor’s basic attitude is.” (Participant 4)

(2) Learning facilitated by immediate feedback

Participants stated that because ChatGPT gave immediate feedback on their utterances, they could quickly check their own responses. They also reported that they could notice ineffective communication patterns such as giving advice and could establish criteria for choosing more appropriate responses in subsequent counseling.

“Since I got feedback on my responses right away, I could think a bit more about what kinds of questions to ask.” (Participant 2)

“During counseling, I unconsciously end up giving advice, but the immediate feedback makes me realize I shouldn’t do that next time.” (Participant 4)

(3) Skill development through repeated practice

Participants stated that training using ChatGPT could be conducted without constraints of time and place and that they could practice repeatedly. They also noted that being able to respond after thinking things through eased the pressure of making mis-

takes, making it useful for preliminary practice before meeting actual clients.

“It was nice because I could take longer to think and still continue the conversation.” (Participant 1)

“I liked that I could practice anytime and anywhere.” (Participant 3)

“There was no burden even when I made mistakes. Because I kept receiving feedback, I didn’t have to worry about whether it was right or wrong. I think it’s a good means of practice before meeting an actual client...” (Participant 5)

(4) Requests for enhanced realism

Participants also reported areas for improvement in training with ChatGPT. They noted that its responses tended to be repetitive and did not sufficiently capture the diverse situations that real clients might present, which limited the practice to some extent.

“There’s a feeling that it keeps skimming the surface. The given prompts tend to circle back to similar answers, going round in circles...” (Participant 2)

“Actual clients can be a bit more complex and present unexpected situations, but ChatGPT sometimes gives predictable and obvious answers.” (Participant 5)

“It would be even better if (the client’s) emotions were also implemented. In a script, the client’s actions and facial expressions, not just their words, are described in parentheses. I wish I could know more about the client’s (nonverbal) emotions.” (Participant 1)

DISCUSSION

This study examined the effects of an LLM (ChatGPT)-based MI training program on undergraduate social welfare students’ empathy competence and MI Confidence. Empathy competence and Global Interviewing Confidence significantly improved after the program, with some effects maintained one month later, and the qualitative analysis identified realistic simulation, immediate feedback, and repeated practice as positive experiences. These results suggest the potential of LLM-based training as a supportive tool in MI education.

Empathy competence significantly improved at both the posttest and the 4-week follow-up, consistent with prior studies reporting positive effects of MI training on empathy [2,3]. Empathy is a core element of the MI spirit and the foundation of

the therapeutic relationship [1]. Participants’ reports of “realistic counseling experiences” and “immersion” suggest that repeatedly practicing core skills such as reflection and affirmation in realistic counseling situations contributed to this improvement, in line with prior studies on generative AI-based virtual patient training [11,12]. The maintenance of the improvement at one month is also meaningful, given repeated reports that skills are difficult to maintain after short-term workshops [6]. The ease of repeated practice in LLM-based environments may have contributed to this maintenance.

For MI Skill Confidence, an upward tendency in mean scores was observed, but the difference was not statistically significant. This can be interpreted in several respects. First, the participants in this study were beginning counselors; once trained, they may come to clearly recognize their own shortcomings, leading to more conservative self-evaluation [22]. Such recalibration of self-evaluation has been repeatedly reported in the field of medical education as well [23], and may be one possibility explaining why confidence was not statistically significant in this study. Meanwhile, some prior studies have reported significant improvements in MI Confidence after education and training; these commonly introduced training methods that provided learners with intensive, individualized feedback and coaching, such as small-group training and practice with real or standardized patients [24,25]. That is, the training methods commonly suggested by prior studies were ‘systematic feedback’ and ‘ongoing supervision’ [7,26]. Future research needs to design programs integrating these elements within a ChatGPT-based environment. The small sample size may also have contributed.

In contrast, Global Interviewing Confidence, measured with a single item, was found to have significantly improved over time. Looking at the related qualitative data, the participants felt less pressure about mistakes, could take time to think, and benefited from repeated practice. These experiences suggest that, although the participants’ confidence in each skill was still limited from a beginner’s perspective, their overall confidence in counseling increased as they felt less pressure about counseling itself and had the opportunity to review their own approach. Confidence is an important predictor of behavior change; it has been measured in various ways and has yielded various results in prior studies. Therefore, future research needs to examine, together, more appropriate confidence measurement indicators and training strategies that reflect the characteristics of LLM-based MI training.

The qualitative analysis showed the positive aspects and lim-

itations of LLM-based MI training in greater detail. Participants experienced a sense of realism similar to actual counseling through conversations with the virtual client and perceived the immediate-feedback and repeated-practice environment as strengths. These results are consistent with the characteristics of deliberate practice, which improves performance through repeated practice and immediate feedback [27,28]. Immediate and specific feedback is also known to be a key element that enhances learning [29], suggesting that ChatGPT can support a self-directed learning environment by providing such feedback in real time.

At the same time, however, participants also experienced limitations, such as ChatGPT's responses being formulaic and repetitive. As Basar et al. [14] pointed out, this shows that current LLMs perform reasonably well at the level of simple reflection but may have limitations in complex emotional inference or the strategic elicitation of change talk. Therefore, at the present stage, it would be more appropriate to use LLM-based MI training as a supplementary learning tool that supports novice learners' repeated practice and early skill acquisition rather than as a complete replacement for skilled supervisors or actual clinical training. Participants also requested that the virtual client's nonverbal cues and a variety of cases be incorporated into the responses for more realistic practice. This suggests that prompt engineering is a key factor influencing the educational effects of LLM-based counseling training. Future programs will therefore need to develop more advanced prompts that include emotional and nonverbal cues and diverse response scenarios.

The limitations of this study are as follows. First, a one-group quasi-experimental design was applied to 15 students at a single university, which limits both generalization and causal inference. Multicenter randomized controlled trials comparing traditional education with AI-integrated education in adequately powered samples are needed. Second, effects were assessed only with self-report measures, so objective change in interviewing performance was not captured. Future studies should apply an objective structured clinical examination with standardized patients, or have trained raters code recorded interviews using the MITI system. Third, because follow-up was limited to 4 weeks, whether the improved competence is sustained in practice remains unclear. Extending follow-up to 3 and 6 months would verify the durability of the effects and clarify the need for refresher training. Fourth, LLMs are continuously updated, so the same prompt may yield different responses later. Prompts also need refinement to reflect clients' nonverbal cues and diverse cases.

Despite these limitations, this study is meaningful in that it confirmed the applicability and initial effects of an LLM (ChatGPT)-based MI training program, suggested that generative AI can serve as a supportive tool for repeated learning and immediate feedback rather than a replacement for instructors, and provides foundational data for the development of AI-based MI education programs and follow-up research.

ORCID

Ho Yeob KANG, <https://orcid.org/0009-0008-1027-8141>

Sohyun WOO, <https://orcid.org/0000-0002-3198-8854>

Hee Jung KIM, <https://orcid.org/0000-0001-6555-1813>

AUTHOR CONTRIBUTIONS

Dr. Hee Jung KIM had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: HYK. Data curation: all authors. Formal analysis: all authors. Investigation: all authors. Methodology: HYK. Project administration: HYK. Resources: HYK and HJK. Software: HYK and HJK. Supervision: HYK. Validation: HYK and HJK. Visualization: HYK and HJK. Writing—original draft: SW and HJK. Writing—review & editing: SW and HJK.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

FUNDING

None.

DATA AVAILABILITY

The dataset supporting the conclusions is available from the corresponding author on reasonable request.

REFERENCES

1. Miller WR, Rollnick S. Motivational interviewing: helping people change and grow. 4th ed. Guilford Press; 2023.

2. Kang HY, Lim SC. Development and evaluation of an integrated motivational interviewing-cognitive behavioral therapy counseling training program for suicide prevention practitioners. *J Soc Work Couns* 2025;9(1):139-61.
3. Kang HY, Kim HJ, Lim SC. Effects of motivational interviewing-based communication training program for enhance counseling competency of social work undergraduate students. *Korean J Soc Welf Educ* 2023;61:1-22.
4. Korean Council on Social Welfare Education. 2022 Social welfare curriculum guidelines [Internet]. Korean Council on Social Welfare Education; 2022 [cited 2026 Jul 2]. Available from: http://kcswe.kr/bbs/board.php?bo_table=b0401&wr_id=36
5. Moyers TB, Manuel JK, Ernst D. Motivational Interviewing Treatment Integrity coding manual 4.2.1. University of New Mexico; 2014.
6. Boyle S, Vseteckova J, Higgins M. Impact of motivational interviewing by social workers on service users: a systematic review. *Res Soc Work Pract* 2019;29(8):863-75.
7. Miller WR, Sorensen JL, Selzer JA, Brigham GS. Disseminating evidence-based practices in substance abuse treatment: a review with suggestions. *J Subst Abuse Treat* 2006;31(1):25-39.
8. Hersherberger PJ, Pei Y, Bricker DA, Crawford TN, Shivakumar A, Vasoya M, et al. Advancing motivational interviewing training with artificial intelligence: ReadMI. *Adv Med Educ Pract* 2021;12:613-8.
9. Suárez-García RX, Chavez-Castañeda Q, Orrico-Pérez R, Valencia-Marin S, Castañeda-Ramírez AE, Quiñones-Lara E, et al. DIALOGUE: a generative AI-based pre-post simulation study to enhance diagnostic communication in medical students through virtual type 2 diabetes scenarios. *Eur J Investig Health Psychol Educ* 2025;15(8):152.
10. Chokkakula S, Chong S, Yang B, Jiang H, Yu J, Han R, et al. Quantum leap in medical mentorship: exploring ChatGPT's transition from textbooks to terabytes. *Front Med (Lausanne)* 2025;12:1517981.
11. Hong H, Shin S. Artificial intelligence-based empathy and compassion training in medical education: impact on patient-centered communication skill development. *J Med Life Sci* 2025;22(3):81-91.
12. Gilbert A, Carnell S, Lok B, Miles A. Using virtual patients to support empathy training in health care education: an exploratory study. *Simul Healthc* 2024;19(3):151-7.
13. Zhu J, Dong A, Wang C, Veldhuizen S, Abdelwahab M, Brown A, et al. The impact of ChatGPT exposure on user interactions with a motivational interviewing chatbot: quasi-experimental study. *JMIR Form Res* 2025;9:e56973.
14. Basar E, Hendrickx I, Krahmer E, Bruijn GJ, Bosse T. To what extent are large language models capable of generating substantial reflections for motivational interviewing counseling chatbots? A human evaluation. *Proceedings of the 1st Human-Centered Large Language Modeling Workshop*; 2024 Aug 15; Bangkok, Thailand. Association for Computational Linguistics; 2024. p. 41-52.
15. Abid A, Baxter SL. Breaking barriers in behavioral change: the potential of artificial intelligence-driven motivational interviewing. *J Glaucoma* 2024;33(7):473-7.
16. Meyer S. Integrating motivational interviewing principles and large language models in automated behaviour change support [dissertation]. University of Regensburg; 2025. English.
17. Fehring RJ. Methods to validate nursing diagnoses. *Heart Lung* 1987;16:625-9.
18. Kim Y, Kim J. Development and validation of empathy scale. *Korea J Couns* 2017;18(5):61-84.
19. Larson E, Martin BA. Measuring motivational interviewing self-efficacy of pre-service students completing a competency-based motivational interviewing course. *Explor Res Clin Soc Pharm* 2021;1:100009.
20. Downe-Wamboldt B. Content analysis: method, applications, and issues. *Health Care Women Int* 1992;13(3):313-21.
21. Guba EG. Criteria for assessing the trustworthiness of naturalistic inquiries. *Educ Commun Technol J* 1981;29(2):75-91.
22. Eva KW, Regehr G. Self-assessment in the health professions: a reformulation and research agenda. *Acad Med* 2005;80(10 Suppl):S46-54.
23. Davis DA, Mazmanian PE, Fordis M, Van Harrison R, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence: a systematic review. *JAMA* 2006;296:1094-102.
24. Bell K, Cole BA. Improving medical students' success in promoting health behavior change: a curriculum evaluation. *J Gen Intern Med* 2008;23(9):1503-6.
25. Black B, Lucarelli J, Ingman M, Briskey C. Changes in physical therapist students' self-efficacy for physical activity counseling following a motivational interviewing learning module. *J Phys Ther Educ* 2016;30(3):28-32.
26. Howard LM, Williams BA. A focused ethnography of baccalaureate nursing students who are using motivational interviewing. *J Nurs Scholarsh* 2016;48(5):472-81.
27. Ericsson KA, Krampe RT, Tesch-Römer C. The role of deliberate practice in the acquisition of expert performance. *Psychol Rev*

- 1993;100(3):363-406.
28. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med* 2004;79(10 Suppl):S70-81.
29. Hattie J, Timperley H. The power of feedback. *Rev Educ Res* 2007;77(1):81-112.

Appendix 1. Prompts used in the ChatGPT-based simulation practice

Session	Simulation task	Prompt entered into ChatGPT
1	Identifying and responding to change talk	Take the role of a client who wants to quit smoking but has been unable to keep it up for various reasons. Respond naturally while I conduct the session. The session will run for about 5 minutes. When the 5 minutes are over, evaluate how effectively change talk was elicited, based on the MITI 4.2.1 coding system. Distinguish change talk from sustain talk in the evaluation, and give specific points for improvement.
2	Open-ended questions	Take the role of a client who wants to quit smoking but is having difficulty. Respond naturally to five open-ended questions from me. After answering the fifth question, evaluate the quality of the open-ended questions based on the MITI 4.2.1 coding system. Explain how far each question drew out change talk, and give examples of more effective questions.
	Affirmation	Take the role of a client who wants to quit smoking but is having difficulty. Respond naturally to five affirmations from me. After the fifth affirmation, evaluate how far the affirmations promoted change talk, based on the MITI 4.2.1 coding system. State whether each affirmation was appropriate, and give examples of more effective affirmations.
3	Simple reflection	Take the role of a client who wants to quit smoking but is having difficulty. Respond naturally to five simple reflections from me. After the fifth simple reflection, evaluate how far the simple reflections promoted change talk, based on the MITI 4.2.1 coding system. State whether each reflection was appropriate as a simple reflection, and point out what could be improved.
	Complex reflection	Take the role of a client who wants to quit smoking but is having difficulty. Respond naturally to five complex reflections from me. After the fifth complex reflection, evaluate the appropriateness of the complex reflections and the degree to which they elicited change talk, based on the MITI 4.2.1 coding system. State whether each reflection was appropriate as a complex reflection, and give examples of more effective complex reflections.
4	Summarizing	Take the role of a client who wants to quit smoking but is having difficulty. Give relatively long answers so that I have enough material to summarize. When I give a summary, evaluate how well it reflected the client's change talk, based on the MITI 4.2.1 coding system. Focus the feedback on the accuracy of the summary, the coverage of key content, and whether change talk was emphasized.
	Integrated role-play	Take the role of a client who wants to quit smoking but is having difficulty. The counselor will conduct a session of about 5 minutes using the core MI skills of open-ended questions, affirmation, simple reflection, complex reflection, and summarizing. When the 5 minutes are over, evaluate the fidelity of the session based on the MITI 4.2.1 coding system. Give specific feedback on the ratio of open to closed questions, the ratio of simple to complex reflections, the appropriateness of affirmations, the degree to which change talk was elicited, and the session as a whole, together with points for improvement.

MI, motivational interviewing; MITI, Motivational Interviewing Treatment Integrity.

Psychosocial Factors Associated with Smoking Cessation Stage among Korean Female Call Center Workers

Sunjoo BOO, PhD, RN

College of Nursing, Research Institute of Nursing Science, Ajou University, Suwon, Korea

ABSTRACT

Background: Female call center workers are exposed to intensive emotional labor, which may increase vulnerability to smoking as a means of coping with work-related stress. However, little is known about how psychosocial factors differ according to smoking cessation stage in this high-risk occupational group. This study compared social nicotine dependence, smoking attitude, smoking abstinence self-efficacy, emotional labor, cognitive emotion regulation (CER) strategies, and social support according to smoking cessation stage among female call center workers and identified factors independently associated with smoking cessation stage.

Methods: In this cross-sectional study, 186 female call center workers with a current or past smoking history were classified into an abstinence group (n=71), a quit-intention group (n=73), and a no-plan group (n=42). Data collected using structured self-report questionnaires were analyzed with the chi-square test, one-way analysis of variance with Scheffé post-hoc tests, Pearson correlation analysis, and multinomial logistic regression.

Results: Social nicotine dependence increased stepwise across the abstinence (13.66 ± 5.97), quit-intention (19.26 ± 5.67), and no-plan (22.86 ± 4.72) groups ($F=39.05$, $P<0.001$), whereas smoking abstinence self-efficacy showed the reverse gradient (35.31 ± 8.16 , 25.74 ± 8.17 , and 22.81 ± 8.68 , respectively; $F=37.91$, $P<0.001$). Adaptive CER strategies were lower in the no-plan group than in the abstinence group ($P=0.027$), whereas emotional labor and social support did not differ significantly among groups. In multinomial logistic regression, higher social nicotine dependence (odds ratio [OR]=1.10 and 1.26 for the quit-intention and no-plan groups, respectively) and lower smoking abstinence self-efficacy (OR=0.89 for both groups) were independently associated with membership in the two current-smoker groups relative to the abstinence group.

Conclusions: Social nicotine dependence and smoking abstinence self-efficacy were independently associated with smoking cessation stage among female call center workers. Workplace smoking cessation interventions tailored to smoking status and quit intention should focus on reducing smoking-rationalizing beliefs and strengthening abstinence self-efficacy to facilitate progression toward smoking abstinence.

Keywords: Smoking cessation, Self efficacy, Psychological adaptation, Occupational health, Social support

INTRODUCTION

National data showed that the self-reported smoking prevalence

among Korean women was 5.9%, whereas the cotinine-verified prevalence was 13.9% [1], suggesting substantial underreporting in the context of persistent stigma surrounding female smoking

Received: July 8, 2026; Revised: August 13, 2026; Accepted: August 14, 2026

Corresponding author: Sunjoo BOO, PhD, RN

College of Nursing, Research Institute of Nursing Science, Ajou University, 206 World cup-ro, Yeongtong-gu, Suwon 16499, Korea

Tel: +82-31-219-7032 Fax: +82-31-219-7020 E-mail: sjboo@ajou.ac.kr

in Korea [1,2]. Female workers employed in service and sales occupations have been reported to smoke at higher rates than female workers in other occupations, and emotional labor and job stress have been identified as correlates of smoking in these workers [3,4]. Call center work is a representative emotional labor occupation in which employees must regulate their emotions in response to customer demands and organizational display rules, and approximately one fifth of female call center workers in Korea were reported to be current smokers, with cigarettes suggested as a means of alleviating the emotional burden of work [3].

Smoking cessation is a behavioral process that involves changes in motivation and smoking behavior over time. The transtheoretical model describes this process as progression from no intention to quit through intention and preparation to action and maintenance [5]. Accordingly, the present study classified participants into three groups based on current smoking status and intention to quit: an abstinence group, a quit-intention group, and a no-plan group. Comparing the psychosocial characteristics of these groups may provide more useful information for developing tailored smoking cessation interventions than a binary comparison between current and former smokers.

Several psychosocial factors may be relevant to this process. Social nicotine dependence refers to cognitive and sociocultural dependence characterized by glamorizing, rationalizing, or minimizing the harms of smoking beyond physical nicotine dependence [6,7]. Smoking abstinence self-efficacy, defined as confidence in maintaining abstinence in tempting or stressful situations, is a consistent predictor of subsequent cessation [8]. Together, these constructs represent two opposing cognitive forces, one rationalizing smoking and the other supporting cessation. In addition, emotional labor [9,10], cognitive emotion regulation (CER) strategies [11], and perceived social support [12] may further shape how work-related emotional strain relates to smoking behavior.

A previous study from this survey population showed that female call center workers who currently smoked had higher social nicotine dependence, more permissive smoking attitudes, and higher emotional labor than ex-smokers and never smokers [13]. However, that study focused on smoking status and therefore could not determine whether psychosocial characteristics differed among female workers maintaining smoking abstinence, current smokers intending to quit, and those with no intention to quit. Understanding these group-specific differences may help identify appropriate intervention targets.

Therefore, this study compared psychosocial factors—including social nicotine dependence, smoking attitude, smoking abstinence self-efficacy, emotional labor, CER strategies, and social support—across smoking cessation groups among female call center workers and identified factors independently associated with group membership. The findings may provide a basis for developing workplace interventions tailored to smoking status and quit intention among female emotional labor workers.

METHODS

Study design and participants

This cross-sectional study analyzed data from an anonymous online survey of female employees of three credit card call centers in Korea, the design of which has been described previously [13]. Participants in the original survey were recruited by convenience sampling from three credit card call centers; unit managers distributed research flyers containing a link to the voluntary anonymous survey. Eligibility—female employees with at least 6 months of work experience—was screened by self-report at the beginning of the survey. Of the 618 employees who completed the initial screening, 30 were ineligible, yielding 588 participants in the original survey.

The present analysis included 186 female workers with a current or past smoking history, defined as having smoked at least 100 cigarettes in their lifetime. Among current smokers, quit intention was reported as within 1 month ($n=9$), within 6 months ($n=14$), sometime in the future ($n=50$), or no intention to quit ($n=42$). Because the study focused on the presence versus absence of quit intention and the two near-term intention categories contained few participants, all current smokers reporting any quit intention were combined into the quit-intention group ($n=73$). Current smokers with no intention to quit formed the no-plan group ($n=42$), and former smokers who were not currently smoking formed the abstinence group ($n=71$); these categories were used as broader analytical groups.

A post-hoc sample size assessment indicated that the available sample exceeded the minimum number required for one-way ANOVA ($n=159$). In addition, the available sample was also considered acceptable for exploratory multinomial logistic regression based on the events-per-variable criterion [14]. This study was approved by the Institutional Review Board (IRB) of Ajou University (IRB No. AJIRB-SBR-SUR-20-561).

Measurements

Social nicotine dependence was measured using the Korean version of the 10-item Kano Test for Social Nicotine Dependence (KTSND) [6,15], scored from 0 to 30, with higher scores indicating stronger tendencies to rationalize and glamorize smoking (Cronbach's $\alpha=0.88$). Smoking attitude was measured using the 7-item smoking attitude scale derived from the Teenage Attitudes and Practices Survey and translated into Korean, as described previously [13], with higher scores indicating a more permissive attitude toward smoking (Cronbach's $\alpha=0.82$). Smoking abstinence self-efficacy was measured using a 9-item scale based on the relapse self-efficacy model [16,17] (range, 9–45), with higher scores indicating greater confidence in remaining abstinent from smoking (Cronbach's $\alpha=0.90$). Emotional labor was measured using the 14-item Emotional Labor Scale developed by Brotheridge and Lee [18] and validated in Korean [19], rated on a 5-point scale, with higher mean scores indicating a greater degree of emotional labor (Cronbach's $\alpha=0.84$). CER strategies were measured using the Korean version [20] of the Cognitive Emotion Regulation Questionnaire [11], which comprises adaptive strategies and maladaptive strategies (Cronbach's $\alpha=0.89$ and 0.80 , respectively). Social support was measured using the 12-item Multidimensional Scale of Perceived Social Support [21], which assesses support from family, friends, and significant others, with higher scores indicating greater perceived support (Cronbach's $\alpha=0.93$). General and occupational characteristics included age, marital status, education, household income, perceived health, sedentary time, drinking days per month, task type (inbound or outbound), job satisfaction, working period, and number of customers handled per day.

Statistical analysis

General characteristics were summarized as frequencies with percentages or means with standard deviations, and their homogeneity across the three groups was tested using the chi-square test and one-way ANOVA. Differences in the major study variables across groups were tested using one-way ANOVA with Scheffé post-hoc tests. Relationships among the study variables were examined using Pearson correlation coefficients. To identify factors independently associated with smoking cessation group, multinomial logistic regression was performed with the abstinence group as the reference category; social nicotine dependence, abstinence self-efficacy, emotional labor, adaptive and maladaptive CER strategies, social support, and drinking days per month were entered as covariates. Smoking

attitude was excluded from the model because of its strong correlation with social nicotine dependence ($r=0.711$), which raised concern about multicollinearity [22]. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp.), and a two-sided $P<0.05$ was considered statistically significant.

RESULTS

General and occupational characteristics

The mean age of the participants was 37.64 ± 8.40 years; 41.4% were living with a spouse, 48.9% had a college education or higher, and 42.5% had a monthly household income of 4 million Korean won or more. Half of the participants (50.0%) rated their health as fair, and the mean sedentary time was 8.16 ± 2.61 hours per day. Inbound tasks accounted for 62.9% and outbound tasks for 37.1% of the participants, 50.0% were satisfied with their job, and the mean working period was 63.45 ± 54.55 months with an average of 94.78 ± 66.48 customers handled per day. None of the general or occupational characteristics, including perceived health ($P=0.778$), differed significantly among the three groups, except for drinking days per month, which was significantly higher in the no-plan group (7.70 ± 8.07 days) than in the abstinence group (4.11 ± 5.86 days) ($F=3.45$, $P=0.034$) (Table 1).

Differences in major study variables by smoking cessation stage

Social nicotine dependence increased stepwise and significantly across the abstinence (13.66 ± 5.97), quit-intention (19.26 ± 5.67), and no-plan (22.86 ± 4.72) groups ($F=39.05$, $P<0.001$; all pairwise comparisons significant). Smoking attitude was significantly less permissive in the abstinence group (7.46 ± 4.41) than in the quit-intention (11.14 ± 3.64) and no-plan (12.76 ± 3.38) groups ($F=28.59$, $P<0.001$), and smoking abstinence self-efficacy was significantly higher in the abstinence group (35.31 ± 8.16) than in the two current-smoker groups (25.74 ± 8.17 and 22.81 ± 8.68) ($F=37.91$, $P<0.001$). Adaptive CER strategies were significantly lower in the no-plan group (62.93 ± 10.88) than in the abstinence group (68.30 ± 11.09) ($F=3.67$, $P=0.027$), whereas emotional labor ($P=0.070$), maladaptive CER strategies ($P=0.872$), and social support ($P=0.549$) did not differ among the groups (Table 2).

Table 1. General and occupational characteristics of the participants by smoking cessation stage (n=186)

Characteristics	Total (n=186)	Abstinence ^a (n=71)	Quit intention ^b (n=73)	No plan ^c (n=42)	χ^2 or F	P-value	Post-hoc
Age (yr)	37.64±8.40	38.10±8.89	36.92±8.44	38.12±7.55	0.44	0.644	-
Marital status, living with spouse	77 (41.4)	34 (47.9)	32 (43.8)	11 (26.2)	5.42	0.067	-
Education, ≥college	91 (48.9)	34 (47.9)	41 (56.2)	16 (38.1)	3.53	0.171	-
Monthly household income, ≥4 million KRW	79 (42.5)	32 (45.1)	34 (46.6)	13 (31.0)	2.98	0.225	-
Perceived health					1.77	0.778	-
Good	47 (25.3)	21 (29.6)	16 (21.9)	10 (23.8)			
Fair	93 (50.0)	33 (46.5)	40 (54.8)	20 (47.6)			
Poor	46 (24.7)	17 (23.9)	17 (23.3)	12 (28.6)			
Sedentary time (hr/day)	8.16±2.61	7.90±2.27	8.48±3.20	8.04±1.85	0.93	0.395	-
Drinking (day/mo)	5.67±7.22	4.11±5.86	6.08±7.67	7.70±8.07	3.45	0.034	a<c
Task type							
Inbound	117 (62.9)	49 (69.0)	45 (61.6)	23 (54.8)	2.38	0.304	-
Outbound	69 (37.1)	22 (31.0)	28 (38.4)	19 (45.2)			
Job satisfaction, satisfied	93 (50.0)	40 (56.3)	38 (52.1)	15 (35.7)	4.69	0.096	-
Working period (mo)	63.45±54.55	65.56±61.75	65.06±50.90	57.14±48.01	0.36	0.696	-
Customers per day	94.78±66.48	93.45±58.74	93.81±72.20	98.82±69.91	0.10	0.908	-

Values are presented as mean±standard deviation or number (%).

KRW, Korean won.

^{a-c}Post-hoc comparisons were performed using the Scheffé test.

Table 2. Differences in major study variables by smoking cessation stage (n=186)

Variables	Total (n=186)	Abstinence ^a (n=71)	Quit intention ^b (n=73)	No plan ^c (n=42)	F	P-value	Post-hoc
Social nicotine dependence	17.94±6.64	13.66±5.97	19.26±5.67	22.86±4.72	39.05	<0.001	a<b<c
Smoking attitude	10.10±4.44	7.46±4.41	11.14±3.64	12.76±3.38	28.59	<0.001	a<b,c
Smoking abstinence self-efficacy	28.73±9.79	35.31±8.16	25.74±8.17	22.81±8.68	37.91	<0.001	a>b,c
Emotional labor	3.44±0.55	3.40±0.51	3.55±0.54	3.32±0.63	2.70	0.070	-
Adaptive CER strategies	66.94±11.08	68.30±11.09	67.92±10.78	62.93±10.88	3.67	0.027	a>c
Maladaptive CER strategies	49.61±9.65	49.76±9.82	49.86±9.45	48.93±9.88	0.14	0.872	-
Social support	64.29±16.69	65.15±17.00	64.88±16.87	61.81±15.97	0.60	0.549	-

Values are presented as mean±standard deviation.

CER, cognitive emotion regulation.

^{a-c}Post-hoc comparisons were performed using the Scheffé test.

Correlations among study variables

Social nicotine dependence was strongly and positively correlated with smoking attitude ($r=0.711$, $P<0.01$) and negatively correlated with abstinence self-efficacy ($r=-0.599$, $P<0.01$); smoking attitude was also negatively correlated with abstinence self-efficacy ($r=-0.499$, $P<0.01$). Adaptive CER strategies were positively correlated with abstinence self-efficacy ($r=0.174$, $P<0.05$), emotional labor ($r=0.389$, $P<0.01$), and social support ($r=0.393$, $P<0.01$), and maladaptive CER strategies were positively correlated with emotional labor ($r=0.318$, $P<0.01$). Emotional labor and social support were not significantly correlated with the smoking-related variables in the total sample (Table 3).

Factors associated with smoking cessation stage

In the multinomial logistic regression with the abstinence group as the reference (likelihood ratio chi-square=102.03, $P<0.001$; McFadden pseudo R-squared=0.256), higher social nicotine dependence was independently associated with membership in the quit-intention group (odds ratio [OR]=1.10; 95% confidence interval [CI], 1.02–1.19; $P=0.012$) and, more strongly, in the no-plan group (OR=1.26; 95% CI, 1.13–1.40; $P<0.001$). Lower abstinence self-efficacy was associated with membership in both current-smoker groups (OR=0.89; 95% CI, 0.85–0.94 and OR=0.89; 95% CI, 0.84–0.96, respectively). Emotional labor was not significantly associated with membership in the quit-intention group, although the point estimate was elevated and the CI was wide (OR=2.18; 95% CI, 0.88–5.41; $P=0.093$). CER strat-

Table 3. Correlations among major study variables (n=186)

Variables	1	2	3	4	5	6	7
1. Social nicotine dependence	1						
2. Smoking attitude	0.711**	1					
3. Smoking abstinence self-efficacy	-0.599**	-0.499**	1				
4. Emotional labor	-0.008	0.069	-0.028	1			
5. Adaptive CER strategies	-0.122	-0.030	0.174*	0.389**	1		
6. Maladaptive CER strategies	-0.001	0.095	-0.060	0.318**	0.363**	1	
7. Social support	-0.005	0.057	0.071	0.143	0.393**	-0.015	1

Values are Pearson correlation coefficients.

CER, cognitive emotion regulation.

* $P < 0.05$; ** $P < 0.01$.

Table 4. Multinomial logistic regression analysis of psychosocial factors associated with smoking cessation stage (n=186)

Variables	Quit intention vs. abstinence OR (95% CI)	P-value	No plan vs. abstinence OR (95% CI)	P-value
Social nicotine dependence	1.10 (1.02–1.19)	0.012	1.26 (1.13–1.40)	<0.001
Smoking abstinence self-efficacy	0.89 (0.85–0.94)	<0.001	0.89 (0.84–0.96)	0.001
Emotional labor	2.18 (0.88–5.41)	0.093	1.22 (0.41–3.64)	0.715
Adaptive CER strategies	1.01 (0.96–1.06)	0.733	0.97 (0.92–1.03)	0.327
Maladaptive CER strategies	0.97 (0.92–1.02)	0.211	0.98 (0.92–1.04)	0.562
Social support	0.99 (0.97–1.02)	0.626	1.00 (0.97–1.03)	0.943
Drinking, days/month	1.05 (0.99–1.11)	0.096	1.05 (0.99–1.12)	0.083

Reference category: abstinence group. Model fit: likelihood ratio $\chi^2=102.03$, $P < 0.001$; McFadden pseudo $R^2=0.256$; Akaike information criterion=328.28; Bayesian information criterion=379.89.

CER, cognitive emotion regulation; CI, confidence interval; OR, odds ratio.

egies, social support, and drinking days were not independently associated with group membership after adjustment (Table 4).

DISCUSSION

This study found that cessation stage among female call center workers was mainly distinguished by social nicotine dependence and abstinence self-efficacy rather than by emotional labor or perceived social support alone. Social nicotine dependence increased stepwise from the abstinence group to the quit-intention and no-plan groups, whereas abstinence self-efficacy showed the opposite pattern, and both factors independently distinguished the two current-smoker groups from the abstinence group in multivariable analysis.

The first major finding was the strong role of social nicotine dependence. Each 1-point increase was associated with higher odds of belonging to the current-smoker groups, particularly the no-plan group (OR=1.26). This is consistent with previous KTSND studies showing that scores differ by smoking status and reflect cognitive rationalization of smoking [6,7,15], and it extends the earlier status-based comparison in this population, in which social nicotine dependence rose from never smokers

through ex-smokers to current smokers [13], by showing that the gradient extends across the three cessation groups. Because the KTSND can be assessed in former smokers, it may be useful both for identifying smokers resistant to cessation and for monitoring residual smoking-rationalizing beliefs among female workers maintaining abstinence as a marker of relapse risk. Reducing social nicotine dependence may require more than information about the harms of tobacco; cognitive restructuring of beliefs such as “smoking relieves stress” or “smoking is part of workplace breaks” is likely needed.

Abstinence self-efficacy was the second key factor. The abstinence group reported the highest self-efficacy, and lower self-efficacy independently predicted membership in both current-smoker groups even after accounting for social nicotine dependence, emotional labor, CER strategies, social support, and drinking, consistent with social cognitive theory and meta-analytic evidence [8,23]. The negative correlation between social nicotine dependence and self-efficacy further suggests that rationalizing beliefs may undermine confidence in quitting. Interventions for smokers with no intention to quit may therefore need to weaken smoking-rationalizing cognitions first and then build mastery through small, achievable abstinence tasks.

Emotional labor did not differ among the groups and was not an independent predictor; nevertheless, its OR for the quit-intention group was of moderate magnitude ($OR=2.18$). This does not imply that emotional labor is irrelevant; rather, it may operate as a contextual stressor whose effect depends on cognitive appraisal and coping resources. Emotional labor was positively correlated with both adaptive and maladaptive CER strategies, indicating that workers under higher emotional demands mobilize more cognitive coping overall, and prior research has linked surface acting and emotional dissonance to impaired well-being [9,10]. For cessation, the critical question may be not whether emotional labor is high but whether workers respond to it through adaptive regulation or through smoking-rationalizing beliefs and cigarette use; mediation or moderation models should be tested in future studies. The elevated but imprecise OR for the quit-intention group should therefore be interpreted as a possible trend rather than evidence of an independent effect; limited precision and statistical power may have contributed to the non-significant result.

Adaptive CER strategies were lower in the no-plan group in univariable analysis but not independently associated with group membership after adjustment, suggesting that adaptive cognitive coping is a supportive resource rather than a direct determinant of group membership. The attenuation may partly reflect conceptual overlap with abstinence self-efficacy, because cognitive reappraisal and coping processes can support confidence in managing high-risk situations [8,11,20,23]. CER training may still be clinically useful when explicitly linked to self-efficacy-building exercises. Such training could include identifying automatic smoking-related thoughts after difficult calls, practicing positive reappraisal and refocusing on an action plan, rehearsing brief urge-management statements, and recording successful smoke-free coping episodes to build mastery.

Perceived social support did not differ by cessation stage and was not independently associated with group membership. This likely indicates that general support is less sensitive than cessation-specific support, whose type, source, and specificity determine its effect [12]. General support may not translate into quitting unless it specifically helps workers manage urges after difficult calls or maintain smoke-free routines; interventions may need to assess and strengthen such behavior-specific support. Similarly, drinking frequency differed among groups in univariable comparison but not in the adjusted model, suggesting shared variance with the cognitive determinants; given the well-documented co-use of alcohol and tobacco and its contri-

bution to relapse [24], brief alcohol-risk counseling may still be a useful component of workplace programs.

These findings support workplace interventions tailored to smoking status and quit intention. For smokers with no intention to quit, the first target should be smoking-rationalizing beliefs, followed by gradual enhancement of abstinence self-efficacy. For smokers intending to quit, preparation for high-risk situations, strengthening of abstinence confidence, and practice of adaptive CER are indicated. For female workers maintaining abstinence, relapse prevention should include monitoring residual social nicotine dependence and reinforcing alternatives to smoking during emotionally demanding work situations. In practical terms, these components could be delivered within the natural rhythm of call center work rather than as separate clinic visits. For example, brief (5–10 minute) post-call debriefs led by supervisors or trained peer facilitators could help workers reframe smoking-rationalizing beliefs (e.g., challenging the notion that a cigarette is the only way to recover after a difficult call); short micro-sessions during scheduled work breaks could offer alternative stress-relief routines—paced breathing, light stretching, or peer conversation—to substitute for smoking breaks; and posted or mobile app-delivered prompts could reinforce messages that lower social nicotine dependence and acknowledge small abstinence milestones. Embedding cessation support into existing work breaks and debriefs in this way may improve its feasibility and reach in this time-constrained workforce. Cessation should be framed not as an issue of individual willpower alone but as a behavior shaped by the cognitive and emotional conditions of work.

This study has several limitations. First, participants were recruited through convenience sampling from a limited occupational context, and response rates could not be calculated because the number of employees who received or viewed the invitation was unavailable; therefore, self-selection bias cannot be excluded and generalizability is limited. Second, the cross-sectional design precludes causal inference; whether cognitive factors led to cessation or cessation reshaped cognition remains unclear. Third, smoking status was self-reported and may be underreported given the stigma against female smoking in Korea [1]. Fourth, the relatively small no-plan group may have limited power to detect weaker associations. Nevertheless, this study is meaningful in that it simultaneously examined cognitive, emotional, and social correlates of cessation stage in an understudied group of female emotional labor workers. In conclusion, social nicotine dependence and abstinence self-efficacy were the most robust correlates of smoking cessation group membership, and

workplace cessation interventions for female call center workers should prioritize cognitive restructuring of smoking-rationalizing beliefs and enhancement of abstinence self-efficacy, incorporating adaptive emotion regulation tailored to emotionally demanding work.

ORCID

Sunjoo BOO, <https://orcid.org/0000-0002-0402-614X>

AUTHOR CONTRIBUTIONS

Dr. Sunjoo BOO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Author reviewed this manuscript and agreed to individual contributions.

Conceptualization: SB. Writing—original draft: SB. Writing—review & editing: SB.

CONFLICTS OF INTEREST

Sunjoo BOO is the Associate Editor of this journal and was not involved in the peer review or editorial decision-making process for this article. No other potential conflicts of interest relevant to this article were reported.

FUNDING

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the South Korean government (MSIT) (2020R1F1A1075517).

DATA AVAILABILITY

The dataset supporting the conclusions is available from the corresponding author on reasonable request.

ACKNOWLEDGMENTS

The author thanks the participating call center employees and managers for their cooperation in this study.

A related article based on the same survey has been published (PLoS One. 2022;17(7):e0267685).

REFERENCES

1. Jung-Choi KH, Khang YH, Cho HJ. Hidden female smokers in Asia: a comparison of self-reported with cotinine-verified smoking prevalence rates in representative national data from an Asian population. *Tob Control* 2012;21(6):536-42.
2. Park JE, Jeong WM, Choi YJ, Kim SY, Yeob KE, Park JH. Tobacco use in Korea: current epidemiology and public health issues. *J Korean Med Sci* 2024;39(45):e328.
3. Boo S, Oh H. Women's smoking: relationships among emotional labor, occupational stress, and health promotion. *Workplace Health Saf* 2019;67(7):361-70.
4. Kim H, Lee KS. Association of stress management with success of smoking cessation in Korean female emotional labor workers for service and sales. *Int J Environ Res Public Health* 2021;18(6):3023.
5. Prochaska JO, DiClemente CC. Stages and processes of self-change of smoking: toward an integrative model of change. *J Consult Clin Psychol* 1983;51(3):390-5.
6. Yoshii C, Kano M, Isomura T, Kunitomo F, Aizawa M, Harada H, et al. Innovative questionnaire examining psychological nicotine dependence, "The Kano Test for Social Nicotine Dependence (KTSND)". *J UOEH* 2006;28(1):45-55.
7. Otani T, Yoshii C, Kano M, Kitada M, Inagaki K, Kurioka N, et al. Validity and reliability of Kano Test for Social Nicotine Dependence. *Ann Epidemiol* 2009;19(11):815-22.
8. Gwaltney CJ, Metrik J, Kahler CW, Shiffman S. Self-efficacy and smoking cessation: a meta-analysis. *Psychol Addict Behav* 2009;23(1):56-66.
9. Grandey AA. Emotion regulation in the workplace: a new way to conceptualize emotional labor. *J Occup Health Psychol* 2000;5(1):95-110.
10. Hülshager UR, Schewe AF. On the costs and benefits of emotional labor: a meta-analysis of three decades of research. *J Occup Health Psychol* 2011;16(3):361-89.
11. Garnefski N, Kraaij V, Spinhoven P. Negative life events, cognitive emotion regulation and emotional problems. *Pers Individ Dif* 2001;30(8):1311-27.
12. Westmaas JL, Bontemps-Jones J, Bauer JE. Social support in smoking cessation: reconciling theory and evidence. *Nicotine Tob Res* 2010;12(7):695-707.
13. Oh H, Boo S. Smoking in the workplace: a study of female call center employees in South Korea. *PLoS One* 2022;17(7):e0267685.
14. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A

- simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol* 1996;49(12):1373-9.
15. Jeong JH, Choi SB, Jung WY, Byun MG, Park MS, Kim YS, et al. Evaluation of social nicotine dependence using the Kano Test for Social Nicotine Dependence (KTSND-K) questionnaire in Korea. *Tuberc Respir Dis* 2007;62(5):365-73.
 16. Kim MS, Kwon JH. The outcome study of cognitive behavioral and behavioral smoking abstinence program. *Korean J Clin Psychol* 2006;25(1):1-23.
 17. Velicer WF, Diclemente CC, Rossi JS, Prochaska JO. Relapse situations and self-efficacy: an integrative model. *Addict Behav* 1990;15(3):271-83.
 18. Brotheridge CM, Lee RT. Development and validation of the emotional labour scale. *J Occup Organ Psychol* 2003;76(3):365-79.
 19. Lee J, Han EM, Hong H, Lee I. Validation of the Korean version of the emotional labor scale (ELS). *Korean J Health Psychol* 2016;21(1):243-56.
 20. Ahn HN, Lee NB, Joo HS. Validation of the cognitive emotion regulation questionnaire in a Korean population. *Korean J Couns* 2013;14(3):1773-94.
 21. Zimet GD, Dahlem NW, Zimet SG, Farley GK. The multi-dimensional scale of perceived social support. *J Pers Assess* 1988;52(1):30-41.
 22. Dormann CF, Elith J, Bacher S, Buchmann C, Carl G, Carré G, et al. Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography* 2013;36(1):27-46.
 23. United States Public Health Service Office of the Surgeon General, National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health. Smoking Cessation: a report of the surgeon general. US Department of Health and Human Services; 2020.
 24. McKee SA, Weinberger AH. How can we use our knowledge of alcohol-tobacco interactions to reduce alcohol use? *Annu Rev Clin Psychol* 2013;9:649-74.

Occupational Stress, Work-Life Balance, and Intention to Stay among Nurses during the COVID-19 Pandemic: A Cross-Sectional Study

Kyoung Hye MIN, RN¹, Seon Hee KIM, RN, MS¹, Young KO, RN, PhD², and Myung Jin JANG, RN, PhD³

¹Department of Nursing, Gachon University Gil Medical Center, Incheon, Korea

²Research Institute of AI and Nursing Science, College of Nursing, Gachon University, Incheon, Korea

³Regional Trauma Center, Gachon University Gil Medical Center, Incheon, Korea

ABSTRACT

Background: This study examined the levels of occupational stress, work-life balance, and intention to stay among nurses working at tertiary hospitals during the COVID-19 pandemic, and investigated the associations among these variables.

Methods: This descriptive correlational study included 240 nurses working at a tertiary general hospital. Data were collected on participants' general characteristics, occupational stress, work-life balance, and intention to stay. Descriptive statistics, t-tests, one-way analysis of variance, Pearson's correlation coefficients, and multiple regression analysis were performed to examine the associations among occupational stress, work-life balance, and intention to stay while adjusting for participants' general characteristics.

Results: The mean age was 27.85 years, and the mean clinical experience was 4.23 years. Half of the participants had experience caring for patients with COVID-19. Mean scores for occupational stress, work-life balance, and intention to stay were 87.51, 87.34, and 29.99, respectively. Occupational stress was negatively correlated with work-life balance ($r=-0.41$, $P<0.001$), whereas neither occupational stress nor work-life balance was significantly correlated with intention to stay. Multiple regression analysis showed that age was associated with intention to stay ($\beta=0.19$, $P=0.029$), but the model explained only 3.2% of the variance (adjusted $R^2=0.03$).

Conclusions: Occupational stress and work-life balance were not significantly associated with intention to stay among nurses during the COVID-19 pandemic. Although age was significantly associated with intention to stay, the regression model explained only a small proportion of the variance. Further studies are needed to identify additional factors associated with nurses' intention to stay.

Keywords: COVID-19, Nurses, Occupational stress, Work-life balance, Intention

INTRODUCTION

In public health crises such as infectious disease outbreaks, the workload and psychological stress of healthcare professionals increase significantly. In particular, continuous exposure to in-

fection risks, the use of personal protective equipment, and high work intensity act as major factors that exacerbate physical and mental fatigue among healthcare professionals. This phenomenon was most notably observed during the Coronavirus Disease-19 (COVID-19) pandemic, which began in December 2019

Received: May 14, 2026; **Revised:** July 9, 2026; **Accepted:** July 21, 2026

Corresponding author: Young KO, RN, PhD

College of Nursing, Gachon University, 191 Hambangmoe-ro, Yeonsu-gu, Incheon 21936, Korea

Tel: +82-32-820-4205 Fax: +82-32-820-4201 E-mail: youngko@gachon.ac.kr

and spread globally [1-3]. At that time, healthcare workers were reported to have experienced high levels of stress and workload while simultaneously performing infection prevention and patient treatment. In Korea as well, high levels of stress and burnout among healthcare workers were reported during the spread of COVID-19 due to excessive workload, staffing shortages, and exposure to infection risks [1,4]. Particularly in the context of infectious disease response, recurring staff shortages and increased workloads make maintaining an adequate nursing workforce a critical challenge. Therefore, sustaining nurses' intention to stay is essential for maintaining workforce stability and ensuring continuity and quality of patient care during public health emergencies.

Nurses' intention to stay in their current nursing profession refers to the intention to stop seeking other jobs or to stay in the nursing profession. Intention to stay is a motivating factor for positive behaviors toward employment [5-7]. Unlike turnover intention, which reflects an employee's intention to leave the organization in response to unfavorable working conditions, intention to stay represents a positive psychological willingness to remain and continue contributing to the organization. Accordingly, intention to stay is recognized as an important indicator of nursing workforce sustainability.

Although turnover intention has been extensively investigated among nurses, relatively few studies have specifically examined intention to stay [8,9]. According to some prior studies, nurses' intention to stay is reported to be influenced by various factors such as clinical experience, marital status, department, occupational stress, and work-life balance [9-12]. However, evidence regarding the direct relationship between occupational stress, work-life balance, and intention to stay remains limited, particularly during public health crises such as the COVID-19 pandemic.

Occupational stress refers to the physiological and psychological burden experienced during the course of work, and it has been reported that nurses experience higher levels of occupational stress than other healthcare professions [13]. In particular, nurses who cared for COVID-19 patients were found to have experienced high work burdens and stress [14,15]. Work-life balance is a concept that refers to the harmony between an individual's life and work [16], and it has been reported that Korean nurses have a lower level of work-life balance compared to other professions due to shift work, night work, and holiday work [17]. In the context of infectious disease outbreaks, occupational stress may increase and work-life balance may deteriorate,

potentially reducing nurses' intention to stay and threatening workforce stability.

Given that intention to stay and turnover intention may reflect different psychological and organizational processes, findings from turnover intention studies cannot necessarily be generalized to intention to stay. Furthermore, empirical evidence regarding these relationships during public health emergencies such as the COVID-19 pandemic remains limited. Therefore, this study aims to identify the levels of occupational stress and work-life balance among nurses at tertiary hospitals during the COVID-19 pandemic, and to examine the relationships among occupational stress, work-life balance, and intention to stay. The findings are expected to provide evidence for developing strategies for promoting nurses' intention to stay during future infectious disease outbreaks.

METHODS

Study design

This study is a descriptive correlational study designed to analyze occupational stress, work-life balance, and intention to stay among nurses working at tertiary hospitals during the COVID-19 pandemic and to examine the associations among these variables.

Description of participants

The participants were nurses working at tertiary general hospitals. The sample size was calculated using G*power version 3.1.9.7. With a significance level of .05, a medium effect size of 0.15, and a power of 0.95, and 9 predictor variables (2 independent variables and 7 general characteristics) were entered into the calculation. The required sample size for multiple regression analysis was 166. Considering a potential 40% dropout rate during the COVID-19 pandemic, 240 nurses were recruited. All 240 questionnaires were completed and included in the final analysis, with no dropouts.

Measurements

Occupational stress

The Korean version of the Expanded Nursing Stress Scale developed by Kim et al. [18] was used to measure nurses' occupational stress. This scale consists of nine domains comprising 48 items. Responses were rated on a 5-point Likert scale ranging from 0 ("I have not experienced this situation") to 4 ("I am

always stressed”), with higher scores indicating higher occupational stress. Cronbach’s α was 0.95 in the original study [18] and 0.96 in this study.

Work-life balance

Work-life balance among nurses was measured using the Work-Life Balance measurement tool developed by Kim and Park [19]. The tool consists of four domains and 29 items. Responses were rated on a 7-point Likert scale ranging from 0 (“not at all”) to 6 (“very much so”). Cronbach’s α was 0.93 in the original study [19] and 0.96 in this study.

Intention to stay

Intention to stay was measured using the Nurses’ Retention Index developed by Cowin [20] and translated by Kim [21]. The tool consists of six items and is measured on an 8-point Likert scale ranging from 1 point (“not at all”) to 8 points (“very much so”), with higher scores indicating a higher intention to stay. Cronbach’s α was 0.97 in the original study and 0.91 in this study.

General characteristics

General characteristics included age, gender, marital status, clinical experience, position, department, and experience caring for patients with COVID-19, which were treated as covariates in the analysis.

Data collection

Data were collected from October 1 to October 31, 2022, after obtaining approval from the Institutional Review Board (IRB) of Gachon Gil Medical Center (IRB: No. GAIRB 2022-269). After obtaining cooperation from the nursing department of a tertiary general hospital, the necessity and purpose of the study were explained to the participants in writing, and questionnaires were distributed. Completed questionnaires were sealed in envelopes, deposited in a collection box, and retrieved by the researcher 2 weeks later. Participants provided written informed consent before participation.

Data analysis

The collected data were analyzed using IBM SPSS/WIN version 22.0 (IBM Corp.). Descriptive statistics were used to summarize the participants’ general characteristics, occupational stress, work-life balance, and intention to stay. Differences according to participants’ general characteristics were analyzed using the independent t-test and one-way analysis of variance (ANOVA).

Pearson’s correlation coefficients were calculated to examine the relationships among occupational stress, work-life balance, and intention to stay. Multiple regression analysis was performed to examine the associations between occupational stress, work-life balance, and intention to stay after adjusting for participants’ general characteristics.

Ethical statements

The study was approved by the IRB of Gachon Gil Medical Center (IRB: No. GAIRB 2022-269) of the university hospital to which the researcher belongs. In accordance with COVID-19 prevention guidelines, all study information and consent procedures were provided in writing. Confidentiality and anonymity were maintained throughout the study. Participants who completed the questionnaire received a small token of appreciation.

RESULTS

General characteristics of the participants

A total of 240 participants were included in this study, with a mean age of 27.85 ± 5.09 years. The majority of participants were aged 20–29 years (78.3%). Women accounted for 214 (89.2%) of the sample. Most participants were unmarried ($n=215$, 89.6%). The mean clinical experience was 4.23 ± 5.14 years. Regarding position, the majority were staff nurses ($n=219$, 91.2%). In terms of department, 165 participants (68.8%) worked in medical wards. Half of the participants ($n=120$, 50.0%) had experience caring for patients with COVID-19 (Table 1).

Differences in occupational stress, work-life balance, and intention to stay according to general characteristics

Regarding occupational stress, younger participants ($F=6.62$, $P=0.002$), men rather than women ($t=-4.01$, $P<0.001$), unmarried participants rather than married participants ($t=2.50$, $P=0.013$), those with less clinical experience ($F=7.28$, $P<0.001$), those in lower positions ($F=3.99$, $P=0.020$), and those without experience caring for patients with COVID-19 ($t=-4.10$, $P<0.001$) reported higher levels of occupational stress. In terms of work-life balance, men reported significantly higher levels than women ($t=3.03$, $P=0.003$). Regarding intention to stay, higher levels were observed among older participants ($F=5.84$, $P=0.003$), married participants compared with unmarried participants ($t=-1.99$, $P=0.048$), those with greater clinical experience ($F=4.78$, $P=0.003$), and those in higher positions ($F=3.50$, $P=0.032$) (Table 1).

Table 1. Differences in occupational stress, work-life balance, and intention to stay according to general characteristics (N=240)

Characteristic	Categories	Number (%)	Occupational stress		Work-life balance		Intention to stay	
			Mean±SD	t or F (P-value)	Mean±SD	t or F (P-value)	Mean±SD	t or F (P-value)
Age (yr)	20–29 ^a	188 (78.3)	91.11±30.97	6.62 (0.002)	86.65±22.53	0.03 (0.972)	29.53±4.23	5.84 (0.003)
	30–39 ^b	43 (17.9)	75.51±24.48		86.37±24.00		31.42±3.72	
	≥40 ^c	9 (3.8)	69.56±15.05		88.33±12.93		32.78±3.11	
Gender	Woman	214 (89.2)	84.87±29.05	-4.01 (<0.001)	85.83±21.86	3.03 (0.003)	30.01±4.12	0.24 (0.813)
	Man	26 (10.8)	109.23±31.21		99.73±23.81		29.81±4.83	
Marital status	Single	215 (89.6)	89.15±29.98	2.50 (0.013)	87.04±22.13	0.60 (0.551)	29.81±4.30	-1.99 (0.048)
	Married	25 (10.4)	73.40±28.82		89.88±25.36		31.56±2.77	
Clinical experience (yr)	1–3 ^a	150 (62.5)	94.04±28.42	7.28 (<0.001)	87.58±22.08	0.03 (0.993)	29.33±4.27	4.78 (0.003)
	4–6 ^b	47 (19.6)	80.34±35.00		86.81±24.36		30.64±4.03	
	7–9 ^c	16 (6.7)	73.50±22.99		88.00±23.51		30.31±3.77	
	≥10 ^d	27 (11.3)	72.00±23.86		86.52±21.62		32.37±3.27	
Position	SN ^a	219 (91.2)	89.17±30.64	3.99 (0.020)	87.39±22.60	0.04 (0.960)	29.78±4.22	3.50 (0.032)
	CN ^b	18 (7.5)	71.28±17.71		87.33±22.13		32.06±3.23	
	HN ^c	3 (1.3)	63.33±18.61		83.67±18.77		33.33±2.52	
Department	ER	41 (17.1)	91.17±29.53	0.83 (0.505)	87.02±25.14	0.88 (0.478)	28.90±4.76	1.07 (0.370)
	Medical	165 (68.8)	85.45±31.41		86.48±22.58		30.19±4.21	
	Surgery	10 (4.2)	96.10±23.62		99.90±12.34		29.30±3.95	
	ICU	19 (7.9)	94.42±21.87		87.84±20.24		30.74±2.86	
	Others	5 (2.1)	82.00±33.62		91.00±16.16		31.00±2.12	
Experience caring for patients with COVID-19	Yes	120 (50.0)	79.77±28.63	-4.10 (<0.001)	85.90±21.80	0.99 (0.322)	30.23±4.50	0.89 (0.373)
	No	120 (50.0)	95.25±29.83		88.78±23.08		29.75±3.87	

CN, charge nurse; ER, emergency room; HN, head nurse; ICU, intensive care unit, SD, standard deviation; SN, staff nurse.

^{a–d}Post hoc test using the Scheffé method.

Relationships of occupational stress, work-life balance, and intention to stay

The mean occupational stress score was 87.51±30.19, the mean work-life balance score was 87.34±22.45, and the mean intention to stay score was 29.99±4.19 (Table 2). Occupational stress showed a significant negative correlation with work-life balance ($r=-0.41$, $P<0.001$). No significant correlation was found between occupational stress and intention to stay ($r=-0.09$, $P=0.164$) or work-life balance and intention to stay ($r=0.02$, $P=0.810$) (Table 3).

To examine the associations between occupational stress, work-life balance, and intention to stay, multiple regression analysis using the enter method was conducted (Table 4). The Durbin–Watson statistic was 2.26, indicating no autocorrelation of residuals. Tolerance values ranged from 0.56 to 0.79 and variance inflation factors ranged from 1.27 to 1.78. Occupational stress, work-life balance, and general characteristics that showed significant differences—age, marital status, clinical experience, and position—were included in the model after dummy coding. The results of the multiple regression analysis indicated that age was the most significant factor associated with intention to stay ($\beta=0.19$, $P=0.029$). The model explained 3.2% of the variance in

intention to stay (adjusted $R^2=0.03$), and the overall model was statistically significant ($F=2.33$, $P=0.033$).

DISCUSSION

This study examined the relationships among occupational stress, work-life balance, and intention to stay among nurses working at tertiary hospitals designated for COVID-19 care during the pandemic. Overall, occupational stress was negatively associated with work-life balance, whereas neither occupational stress nor work-life balance was significantly associated with intention to stay.

First, the level of occupational stress observed in this study was moderate, differing from previous studies that reported high levels of stress and burnout among nurses during the early stages of the COVID-19 pandemic [22–24]. Unlike earlier studies conducted during periods of greater uncertainty [25], this study was performed after infection control systems had become more stable and nurses had adapted to new clinical routines, including the use of personal protective equipment, which may explain the relatively lower level of occupational stress observed. Nurses with experience caring for patients with

Table 2. Occupational stress, work-life balance, and intention to stay (N=240)

Variable	Mean±SD	Min-Max	Range
Occupational stress	87.51±30.19	4–192	0–192
Death and dying	12.50±4.51	0–24	0–24
Conflict with physicians	5.45±2.71	0–12	0–12
Inadequate emotional preparation	5.79±1.95	0–12	0–12
Problem relating to peers	11.11±3.80	0–20	0–20
Problem relating to supervisors	13.11±5.64	0–28	0–28
Work load	8.47±4.23	0–24	0–24
Uncertainty concerning treatment	11.55±5.03	0–28	0–28
Patients and their families	11.65±5.75	0–32	0–32
Discrimination	7.88±3.47	0–12	0–12
Work-life balance	87.34±22.45	32–144	0–174
Work-home	26.43±5.94	8–39	0–48
Work-leisure	23.58±7.36	8–40	0–48
Work-growth	26.44±8.28	9–45	0–54
Work-life	10.89±3.93	4–20	0–24
Intention to stay	29.99±4.19	19–42	6–48

Max, maximum; Min, minimum; SD, standard deviation.

Table 3. Correlation of occupational stress, work-life balance, and intention to stay (N=240)

Variable	Occupational stress	Work-life balance	Intention to stay
	<i>r</i> (<i>P</i>)	<i>r</i> (<i>P</i>)	<i>r</i> (<i>P</i>)
Occupational stress	1		
Work-life balance	–0.41 (<0.001)	1	
Intention to stay	–0.09 (0.164)	0.02 (0.810)	1

Table 4. Multiple regression analysis of factors associated with intention to stay (N=240)

Variable	Intention to stay					
	B	SE	β	<i>t</i> (<i>P</i> -value)	Tolerance	VIF
Constant	30.51	1.21		25.13 (<0.001)		
Occupational stress	–0.01	0.01	–0.07	–0.93 (0.353)	0.72	1.39
Work-life balance	–0.00	0.01	–0.02	–0.29 (0.769)	0.79	1.27
Age (≥30 yr)	1.90	0.86	0.19	2.20 (0.029)	0.56	1.78
Marital status (married)	0.47	1.03	0.03	0.46 (0.647)	0.72	1.39
Clinical experience (≥4 yr)	–0.88	0.63	–0.10	–1.41 (0.161)	0.77	1.31
Position (CN or HN)	0.78	1.22	0.05	0.64 (0.524)	0.60	1.67
Durbin-Watson's=2.26, R^2 =0.06, adjusted R^2 =0.03, F =2.33 (P =0.033)						

Dummy variable: age (reference=20–29 years), marital status (reference=single), clinical experience (reference=1–3 years), position (reference=staff nurse).

CN, charge nurse; HN, head nurse; SE, standard error; VIF, variance inflation factor.

COVID-19 also reported lower occupational stress. Additional analyses of the present data indicated that nurses with experience caring for patients with COVID-19 were generally older and had longer clinical experience than those without such experience. This finding may reflect greater clinical competence, accumulated coping skills, and adaptation to infection-control practices among experienced nurses [26–29]. However, because the present study did not directly compare nurses with and without COVID-19 patient care experience, this explanation

remains speculative and should be interpreted with caution. Further studies are needed to verify this finding.

Regarding specific stressors, discrimination and problems with peers were identified as the most prominent sources of occupational stress. This differs from previous studies emphasizing workload or physician-related conflict [30]. Frequent staff redeployment and rapid reorganization during the pandemic may have increased interpersonal conflict and disrupted team dynamics [26–28]. These findings suggest that healthcare organi-

zations should address interpersonal and organizational factors as well as workload during future public health emergencies.

Second, work-life balance was relatively high compared with previous studies conducted during the pandemic [31]. This finding may be related to the characteristics of the study sample, which consisted largely of younger nurses with relatively short clinical experience. Early-career nurses may have fewer family responsibilities and greater flexibility in balancing work and personal life [32]. As expected, occupational stress was negatively associated with work-life balance, consistent with previous research [28,32-33]. These findings suggest that reducing occupational stress may also improve nurses' work-life balance.

However, neither occupational stress nor work-life balance was significantly associated with intention to stay. Previous studies have primarily focused on turnover intention rather than intention to stay, making direct comparisons difficult [29,34,35]. One possible explanation is that turnover intention and intention to stay are conceptually distinct constructs. Therefore, occupational stress and work-life balance may have different relationships with intention to stay than with turnover intention. However, the present study was not designed to identify other determinants of intention to stay. Previous systematic reviews have identified several organizational and psychological variables that may be associated with nurses' intention to stay. However, these variables were not examined in the present study. The regression model explained only a small proportion of the variance in intention to stay (adjusted $R^2=0.03$), suggesting that additional factors beyond occupational stress, work-life balance, and the variables included in this study should be investigated in future research. Third, age was the only variable significantly associated with intention to stay. However, because the regression model explained only a small proportion of the variance, age alone is unlikely to account for nurses' decisions to remain in their organizations.

From a practical perspective, strategies to promote nurses' intention to stay should comprehensively address both organizational and individual factors beyond age alone. Interventions aimed at reducing occupational stress may also improve work-life balance. During infectious disease outbreaks, workforce management should consider not only workload but also staff experience and the need for adaptation support in unfamiliar clinical environments. Although the COVID-19 pandemic has ended, nursing shortages and workforce instability remain global challenges. The present findings suggest that improving occupational stress or work-life balance alone may not be sufficient

to enhance nurses' intention to stay. Because the present study did not examine organizational determinants, future studies should investigate organizational and psychological factors that may contribute to nurses' intention to stay.

Despite these contributions, this study has several limitations. The findings were obtained from a single institution, and the sample was largely composed of early-career nurses, which may limit generalizability. In addition, the cross-sectional design precludes causal inferences. Future studies should include more diverse samples across multiple institutions, incorporate broader organizational and psychological variables, and use longitudinal or qualitative approaches to better understand nurses' decisions to remain in their organizations.

In conclusion, occupational stress and work-life balance were not significantly associated with nurses' intention to stay in this sample. Although age showed a significant association with intention to stay, the regression model explained only a small proportion of the variance. These findings suggest that additional factors influencing nurses' intention to stay should be explored in future studies.

ORCID

Kyoung Hye MIN, <https://orcid.org/0009-0006-0118-5627>

Seon Hee KIM, <https://orcid.org/0009-0004-3783-8103>

Young KO, <https://orcid.org/0000-0003-2708-8543>

Myung Jin JANG, <https://orcid.org/0000-0001-5059-0385>

AUTHOR CONTRIBUTIONS

Dr. Young KO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: SHK, YK, and MJJ. Data curation: KHM and SHK. Formal analysis: all authors. Methodology: all authors. Software: YK and MJJ. Writing—original draft: all authors. Writing—review & editing: all authors.

CONFLICTS OF INTEREST

Young KO is the Associate Editor of this journal and was not involved in the peer review or editorial decision-making process for this article. No other potential conflicts of interest relevant to this article were reported.

FUNDING

None.

DATA AVAILABILITY

The data presented in this study are available upon reasonable request from the corresponding author.

ACKNOWLEDGMENTS

We would like to thank all the nurses who participated in the research during the COVID-19 pandemic.

REFERENCES

1. Lee EJ, Cho OY, Wang KH, Jang MJ. Correlation between nurses' posttraumatic stress disorder, depression and social stigma in nursing COVID-19 patients. *J East-West Nurs Res* 2021;27(1):14-21.
2. Schwartz J, King CC, Yen MY. Protecting healthcare workers during the coronavirus disease 2019 (COVID-19) outbreak: lessons from Taiwan's severe acute respiratory syndrome response. *Clin Infect Dis* 2020;71(15):858-60.
3. Kim I, Kim HR. Factors associated with job stress and their effects on mental health among nurses in COVID-19 wards in four hospitals in Korea. *Healthcare (Basel)* 2023;11(10):1500.
4. Hwang S, Kwon KT, Lee SH, Kim SW, Chang HH, Kim Y, et al. Correlates of burnout among healthcare workers during the COVID-19 pandemic in South Korea. *Sci Rep* 2023;13(1):3360.
5. Kim YM, Seo M. Factors influencing the retention intention of nurses in general hospital nurses. *J Digit Converg* 2020;18(12):377-87.
6. Lee MH, Kwon SH. Mediating effect of organizational commitment on the relationship between nurses' clinical characters and retention intention of the small and medium-sized hospital nurses. *J Korean Acad Nurs Adm* 2022;28(2):110-20.
7. Ko JH, Gu MO. Convergence study on mediating effect of clinical competence on the relationship between grit and retention intention among new graduate nurses. *J Korea Converg Soc* 2020;11(4):369-80.
8. Hussein R, Salamonson Y, Hu W, Everett B. Clinical supervision and ward orientation predict new graduate nurses' intention to work in critical care: findings from a prospective observational study. *Aust Crit Care* 2019;32(5):397-402.
9. Yang JS, Jang MJ. The mediating effect of grit on the relationship between work environment and intention to stay at work among regional trauma center nurses: a cross-sectional study. *Korean J Adult Nurs* 2023;35(2):107-16.
10. Choi SO, Kim J. Relationships among job stress, nursing performance, and retention intention of clinical nurses. *J Korean Public Health Nurs* 2013;27(1):142-52.
11. Oh EJ, Jeong KS. The effect of job stress, nursing organizational culture and emotional exhaustion on retention intention among clinical nurses. *J Korea Contents Assoc* 2019;19(7):467-77.
12. Yoon JH, Park H. The influence of leader-member exchange relationship, perceived organizational support, and work-life balance on tertiary hospital nurses' retention intention. *J Korean Acad Fundam Nurs* 2023;30(1):13-23.
13. Han K, Kim T. The effect of emotional labor, job stress and way of coping on the organizational commitment of nurses in a general hospital. *Korean J Stress Res* 2015;23(1):39-48.
14. Kim J, Park M. The impact of newly graduated nurses' job stress, self-efficacy, resilience and social support on depression. *J Korean Soc Nurs Ethic* 2023;3(1):35-45.
15. Mo Y, Deng L, Zhang L, Lang Q, Liao C, Wang N, et al. Work stress among Chinese nurses to support Wuhan in fighting against COVID-19 epidemic. *J Nurs Manag* 2020;28(5):1002-9.
16. Nam MH, Heo HJ. Effect of nurses' work-life balance and nursing performance on happiness index. *J Korean Data Anal Soc* 2022;24(6):2329-42.
17. Park MS, Kim MY, Kim KA, Chun J. Factors of the happiness of youth generations by work-life balance: a cross-national comparison utilizing the better life index and world value survey. *J Fam Resour Manag Policy Rev* 2019;23(2):79-97.
18. Kim KM, Nam KA, Lee E, Jeong GH. Validity and Reliability of the Korean Version of the Expanded Nursing Stress Scale. *J Korean Acad Nurs Adm* 2015;21(5):542-51.
19. Kim CW, Park CY. A study on the development of a 'work-life balance' scale. *J Leis Stud* 2008;5(3):53-69.
20. Cowin L. The effects of nurses' job satisfaction on retention: an Australian perspective. *J Nurs Adm* 2002;32(5):283-91.
21. Kim MJ. The effect of nursing organizational culture on nurses' intention of retention [master's thesis]. Hanyang University; 2006. Korean.
22. Yun S, Ahn SV. Correlation between COVID-19 and nurses' job stress and burnout. *HIRA Res* 2022;2(2):202-18.
23. Kim H, Kim D, Kim M, Kim Y, Bang S, Lee G, et al. Factors Influencing burnout of nurses working in a hospital nationally designated for COVID-19 Patients. *Korean J Adult Nurs*

- 2022;34(1):74-84.
24. Park MH, Seo BN. The influence of self-leadership of nurses in COVID-19 designated hospitals on patient-centered nursing: the mediating effect of nursing professional values and occupational stress. *J Ind Converg* 2023;21(6):61-71.
 25. Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open* 2020;3(3):e203976.
 26. Park MA, Choi E. Nurses' awareness of psychological distress and delirium in cancer patients and job stress. *Asian Oncol Nurs* 2017;17(4):252-62.
 27. Lee SY, Song KJ, Lim CS, Kim BG, Chai YJ, Lee JK, et al. Operation and management of seoul metropolitan city community treatment center for mild condition COVID-19 patients. *J Korean Med Sci* 2020;35(40):e367.
 28. Choi J, Byun HM, Yun EK, Woo KA. Challenges in planning the hospital nursing workforce under the government-led response to COVID-19 in South Korea: a descriptive, qualitative study. *J Adv Nurs* 2025;81(12):8859-70.
 29. Park J, Shin N. A convergence study on the relationships among job stress, resilience and turnover intention of new nurses in general hospital. *J Korea Converg Soc* 2019;10(4):277-84.
 30. Yoon R, Gu M, Park M, Sok S. Experiences of COVID-19 dedicated ward nurse managers in South Korea: a qualitative study. *Front Public Health* 2025;13:1675436.
 31. Lee YM, Chon MY. The effects of leisure activities and work-life balance on the professional quality of life of nurses during the COVID-19 pandemic. *J Korean Soc Living Environ Syst* 2023;30(4):407-16.
 32. You SJ. Work-life balance and professional quality of life among nurses in general hospitals: mediating effects of occupational stress. *Korean J Health Serv Manag* 2021;15(2):1-14.
 33. Park MH, Cho SH. Relationships among grit, job satisfaction, and the intention to stay of clinical nurses in Korea. *J Korean Clin Nurs Res* 2019;25(3):285-93.
 34. Hanoum FC, Rizan M, Handaru AW. The role of work-life balance, work stress, and work-family conflict in creating job satisfaction and their impact on turnover intention in nurses at level I health facilities hospital in Karawang. *Crit Care Nurs Q* 2024;47(4):346-69.
 35. Lee DY, Kim SY. The influences of grit, emotional labor and organizational intimacy on nurses' intention to stay in comprehensive nursing care service units. *Korean J Rehabil Nurs* 2020;23(2):149-57.

Seasonal Trends of Chronic Obstructive Pulmonary Disease and Asthma with a Meteorological Analysis in Korea: Using the National Health Insurance Service–Senior Database 2.0

Taehoon LEE, MD¹, Hayoung SHIM, PhD Candidate^{2,3}, and Belong CHO, MD, PhD^{1,2,3}

¹Department of Family Medicine, Seoul National University Hospital, Seoul, Korea

²Department of Human Systems Medicine, Seoul National University College of Medicine, Seoul, Korea

³SNU Institute on Aging, Seoul National University, Seoul, Korea

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) and asthma can exacerbate the seniors' quality of life and increase socioeconomic burden. We analyzed the seasonal trends of the average medical costs and hospital days, meaning admission days plus outpatient visit days, and the association of them with the meteorological factors.

Methods: The total number of people with COPD and asthma was 104,941 and 301,921, from 2002 to 2019, respectively. The information about hospital days and the medical cost were from the National Health Insurance Service–Senior Database 2.0. The meteorological factors included seasonal average temperature, daily temperature range, rainfall, wind speed, PM10, and PM2.5 from Korea Meteorological Administration and Korean Statistical Information Service. Analysis was done adjusted with age, by Pearson correlation coefficient, Spearman's rank correlation coefficient, generalized linear mixed model, multiple regression, generalized additive mixed model analysis, and paired t-test.

Results: The severity of COPD and asthma appears to be lowest in fall, and winter is the second lowest burdensome season. The seasonal average cost of COPD was related with extreme temperature ($P=0.0421$). The seasonal average hospital days of COPD was related with extreme temperature ($P=0.0267$) and wind speed ($P=0.0103$). Both the seasonal average cost and hospital days of COPD may have negative correlation with humidity and positive correlation with wind speed. For asthma, the seasonal average cost was related with extreme temperature ($P=0.0046$) and the hospital days was related with extreme temperature ($P=0.0074$) and wind speed ($P=0.0373$). Both the average cost and hospital days of asthma had positive correlation with temperature and wind speed, and had negative correlation with humidity.

Conclusions: According to our analysis, seniors with COPD and asthma should also care their respiratory health during spring and winter. We suggest them to avoid extreme temperatures, dry environments, and strong winds to protect their respiratory health, save medical cost, and shorten hospital days.

Keywords: Chronic obstructive pulmonary disease, Asthma, Climate, Aged, Republic of Korea

Received: July 20, 2026; Accepted: July 23, 2026

Corresponding author: Belong CHO, MD, PhD

Department of Family Medicine, Seoul National University Hospital, 101 Daehak-ro, Jongno-gu, Seoul 03080, Korea

Tel: +82-2-2072-2195 Fax: +82-2-766-3276 E-mail: belong@snu.ac.kr

INTRODUCTION

Pneumonia was the third leading cause of death from 2018 in Korea, except deaths from COVID-19. The first and second most cause of death were cancer and heart diseases, respectively. Many patients with cancer and heart diseases also experience pneumonia until death, and pneumonia could be the common cause of death for those patients. Likewise, respiratory health of old people has a significant association with death and quality of life.

Chronic respiratory diseases would exacerbate the respiratory health of old people and it will result as high socio-economic burden and poor quality of life. Chronic obstructive pulmonary disease (COPD) [1,2] and asthma [3] are among the most common chronic respiratory diseases and their socio-economic burden is currently increasing. As the progression of aging society is expected, the burden will increase and respiratory health of old population will be the more important issue in the future.

There are several factors with the prevalence and progression of COPD, genetic factors, age and sex, pulmonary growth and development and environmental factors. The environmental factors are smoking [4], biomass exposure, occupational pollutants and chemicals [5], air pollution [6,7], or socio-demographic index [8].

For asthma, two large factors, host factors and environmental factors, are associated with the prevalence and progression of asthma. Host factors are generally genetic factors [9], obesity [10], and sex [11]. Environmental factors are allergens [12], infection [13], occupational pollutants, stress, smoking, air pollution [14,15], or food.

We focused on the meteorological factors from environmental factors such as temperature, air pollution, humidity or wind speed.

In the big data analysis [7] in Korea, PM10 levels 1 day before acute exacerbation of COPD was associated with acute exacerbation and the monthly mean incidence rate of COPD acute exacerbation showed a similar trend with PM10 1 day prior to the acute exacerbation. In other study [16] examining the association between total suspended particle (TSP) concentrations and the relative risk of hospital admission due to respiratory diseases (COPD, asthma, and bronchitis), the relative risk showed a linear increase with higher TSP concentrations in all study locations.

The study [17] in USA with 12.5 million elderly individuals showed 4.7% increased risk of hospitalization for COPD for every 10 °F increase in ambient temperature. In the study [18] with

1990–2019 Global Burden of Disease data, every 1 °C increase in maximum temperature variability increased the risk of asthma by 5.0% globally, especially for individuals living in high latitude or aged from 50 to 70 years.

In the study [19] in Ganzhou, China, extremely low temperature and low humidity increased the risk of COPD death in Ganzhou city for males and people over 65 years old. In the systematic review about the effect of extreme weather events on asthma [20], extreme weather such as thunderstorm, heat waves or floods, was associated with increasing risks of asthma outcomes with relative risks of 1.18 for asthma events (95% confidence interval [CI] 1.13–1.24), 1.10 for asthma symptoms (95% CI 1.03–1.18), and 1.09 for asthma diagnoses (95% CI 1.00–1.19).

However, some studies suggested that the effect of air pollution, temperature, and other environmental factors does not have significant relationship with COPD and asthma. In the cohort study [21] of London with 812,063 patients without COPD diagnosis, hazard ratios (HR) for general practitioners recorded COPD and PM10, PM2.5 and NO₂ were close to unity, positive for SO₂ (HR=1.07, 95% CI 1.03–1.11, per 2.2 µg/m³), and negative for ozone (HR=0.94, 95% CI 0.98–1.00, per 3 µg/m³). Admissions HRs for PM2.5 and NO₂ remained positive (HRs=1.05 [0.98–1.13] and 1.06 [0.98–1.15] per 1.9 µg/m³ and 10.7 µg/m³, respectively). In the study [22] of southwest China for asthma among older adults, CO and PM10 have a significant effect with risk of hospitalization for asthma on the population aged 65–69, however, there was no statistically significant effect on the population aged over 70. These statistical differences could vary by the region, characteristics of population, statistical evaluation, or measurement method.

This study tried to analyze how COPD and asthma is associated with the season, and some meteorological factors in Korea in little different ways. This study was approved with the Institutional Review Board (IRB) of the Seoul National University Hospital Center for Human Research Protection (IRB No. E-2603-028-1724) and also got approval from National Health Insurance Service (NHIS).

METHODS

Data source

We used the data of National Health Insurance Service-Senior (NHIS-Senior) database (DB) 2.0 of 2002–2019, until COVID-19. It is the cohort database for the research of diseases

with old population established from 2008. It collected the data of people aged 60–80 in 2008 with national health insurance and from 2009–2019, it collected 8% of people aged 60 each year about individual information, healthcare utilization information, or nursing facility status information. It collected the data of 511,953 in 2008 and 545,831 in 2009–2019. The method of collection used stratified random sampling, and stratification was done for sex, age (1 year unit), region (big/medium city/rural area), and income decile.

For the environmental factors, we collected the most data from Korea Meteorological Administration (KMA). It provided the data of temperature, humidity, wind speed, and rainfall. Also we used data about PM2.5, PM10 from Korean Statistical Information Service (KOSIS). Data about PM2.5 and PM10 was provided from 2015 and 2010, respectively.

Independent variable

In Korea, the climatic factors vary significantly with seasonal variation. Therefore, we divided interval of time into every season of 2002–2019. Our data analysis started from the spring of 2002 to the fall of 2019. The range of the spring is from March to May, the summer from June to August, the fall from September to November, and the winter from December to February of the next year. The KMA provided seasonal data of average temperature and average rainfall. Since there were only monthly data for the wind speed and humidity, we averaged the monthly data into seasonal data. Likewise, the seasonal data was established with the monthly data of PM2.5 and PM10 from KOSIS. In Korea, PM2.5 and PM10 has a data only from 2015 and 2010 respectively.

Dependent variable

To evaluate the severity of COPD and asthma, we used the cost of total medical expenses and the number of outpatient visit days and admission days with the main diagnosis of COPD and asthma from the NHIS-Senior DB 2.0. For convenience, we call the number of outpatient visit days plus admission days as the number of hospital days. We considered patients visited hospitals for COPD as patients with main diagnosis code starting with J44, and for asthma, as patients with main diagnosis code starting with J45 and J46. This study divided the study period into four seasons. Accordingly, the expenses and total number of hospital days for COPD and asthma were assigned to each season based on the admission date or outpatient visit date.

During the analysis, we found out the age of seniors should be controlled since the cost burden and the number of hospital days

of COPD and asthma are strongly related with the age of patients. Therefore, the age variable was always analyzed together.

Statistical method

We used Pearson correlation coefficient, Spearman's rank correlation coefficient, generalized linear mixed model (GLIMMIX), multiple regression analysis, generalized additive mixed model (GAMM), and paired t-test. We consider statistical significance if *P*-value is less than 0.05. SAS Enterprise Guide 8.3 (SAS Institute) was used for analysis.

RESULTS

The total number of people with COPD (J44) and asthma (J45 and J46) diagnosis was 104,941 and 301,921, respectively. Table 1 shows the distribution of people with COPD and asthma diagnosis. Since it was the cohort database, each person may have different age group, different address, or different income decile every year. If their age group, address or income decile changed between 2002 and 2019, they may be counted more than once.

Fig. 1 shows the seasonal similarities every year of the meteorological factors. The rainfall and the temperature was high in summer, and low in winter. The daily temperature range was high in spring, and low in summer. The wind speed was high in spring and winter, and low in fall and summer. PM2.5 and PM10 was high in spring and winter, and low in fall and summer. The humidity was highest in summer, followed by fall, and low in spring and winter.

The seasonal variation of average cost and the number of hospital days of COPD and asthma are shown above (Fig. 2).

The average seasonal cost of COPD was low in fall and it was statistically significant ($P < 0.0001$ for the other seasons) with GLIMMIX. The average number of hospital days of COPD was low in fall ($P = 0.0004$ or < 0.0001) and high in spring than winter ($P = 0.0217$) with statistical significance.

The average seasonal cost of asthma was lowest in fall ($P = 0.0004$ or < 0.0001) followed by winter and seems similar in summer and spring with GLIMMIX analysis. The average number of hospital days for asthma was lowest in the fall ($P = 0.0002$ or < 0.0002) and followed a downward-right trend, which was different from the patterns observed in other seasons.

From the analysis, we used `copd_avg_cost`, `copd_avg_adm`, `asthma_avg_cost`, and `asthma_avg_adm` for the variables the seasonal average cost of COPD patients, the seasonal average hospital days of COPD patients, the seasonal average cost of

Table 1. Demographics of study population

	Chronic obstructive pulmonary disease		Asthma	
	Number	Percentage	Number	Percentage
Age group (yr)				
50s	20,855	16.00	106,868	27.14
60s	45,606	34.99	148,894	37.82
70s	48,121	36.92	107,442	27.29
80s	15,491	11.88	29,985	7.62
90s	281	0.22	551	0.14
Sex				
Male	60,151	57.32	118,109	39.12
Female	44,790	42.68	183,812	60.88
Income decile				
0	13,785	8.97	31,108	6.52
1	12,335	8.03	39,721	8.33
2	9,381	6.11	31,485	6.60
3	9,314	6.06	31,134	6.53
4	10,537	6.86	34,445	7.22
5	11,981	7.80	38,109	7.99
6	13,135	8.55	42,370	8.88
7	15,318	9.97	48,732	10.22
8	17,697	11.52	55,669	11.67
9	20,131	13.10	61,302	12.85
10	20,031	13.04	62,869	13.18
Address code				
Seoul	15,652	14.37	57,975	18.24
Busan	6,915	6.35	24,571	7.73
Daegu	5,657	5.19	15,651	4.92
Incheon	4,436	4.07	15,516	4.88
Gwangju	3,201	2.94	8,502	2.68
Daejeon	2,333	2.14	7,211	2.27
Ulsan	1,598	1.47	6,274	1.97
Sejong	168	0.15	418	0.13
Gyeonggi	18,017	16.54	61,090	19.22
Gangwon	5,085	4.67	11,225	3.53
Chungbuk	4,415	4.05	10,025	3.15
Chungnam	6,548	6.01	14,341	4.51
Jeonbuk	5,968	5.48	15,647	4.92
Jeonnam	8,695	7.98	19,062	6.00
Gyeongbuk	10,369	9.52	21,151	6.66
Gyeongnam	8,001	7.35	24,604	7.74
Jeju	1,825	1.68	4,471	1.41
Missing	24		76	

asthma patients, and the seasonal average hospital days of asthma, respectively. The variables `copd_avg_age` and `asthma_avg_age` mean the seasonal average age of COPD patients and the seasonal average age of asthma patients. The variable `temp_range` means the seasonal average daily temperature range. This will be applied to following analysis.

Table 2 shows the association of each meteorological factors with the seasonal average cost and hospital days of COPD and asthma. Age was strongly associated with the cost and the number

of hospital days ($P=0.0003$ or <0.0001). For COPD, age had a positive correlation with the cost and the number of hospital days. For asthma, age had a positive correlation with the cost, but a negative correlation with the number of hospital days.

The cost of COPD and asthma had no statistically significant correlation with all environmental factors we analyzed, the temperature, the daily temperature range, humidity, rainfall, wind speed, PM10, and PM2.5.

The number of hospital days of COPD had a positive correla-

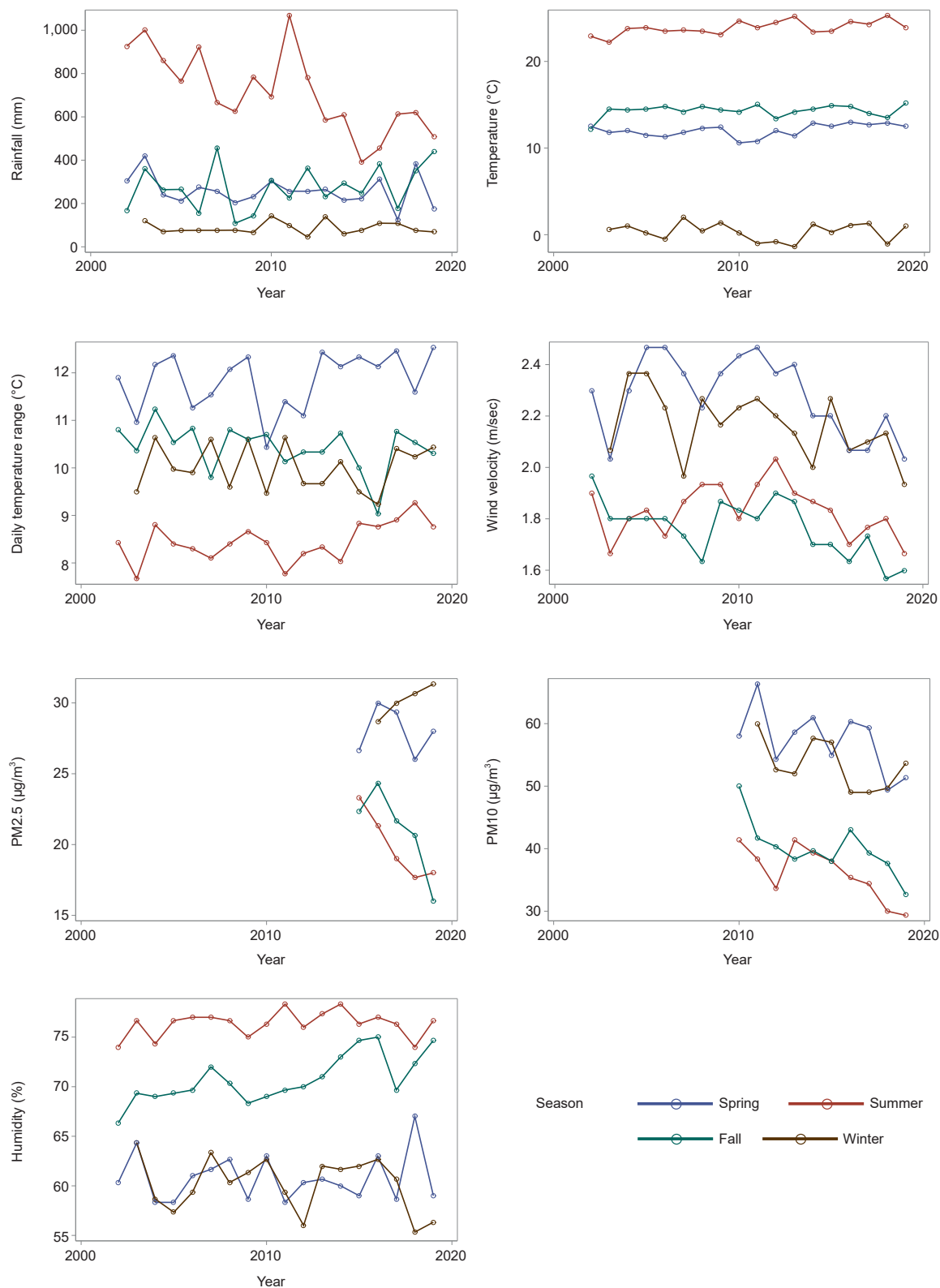


Fig. 1. The seasonal meteorological factors (rainfall, temperature, daily temperature range, wind velocity, PM2.5, PM10, humidity) from 2002 to 2019.

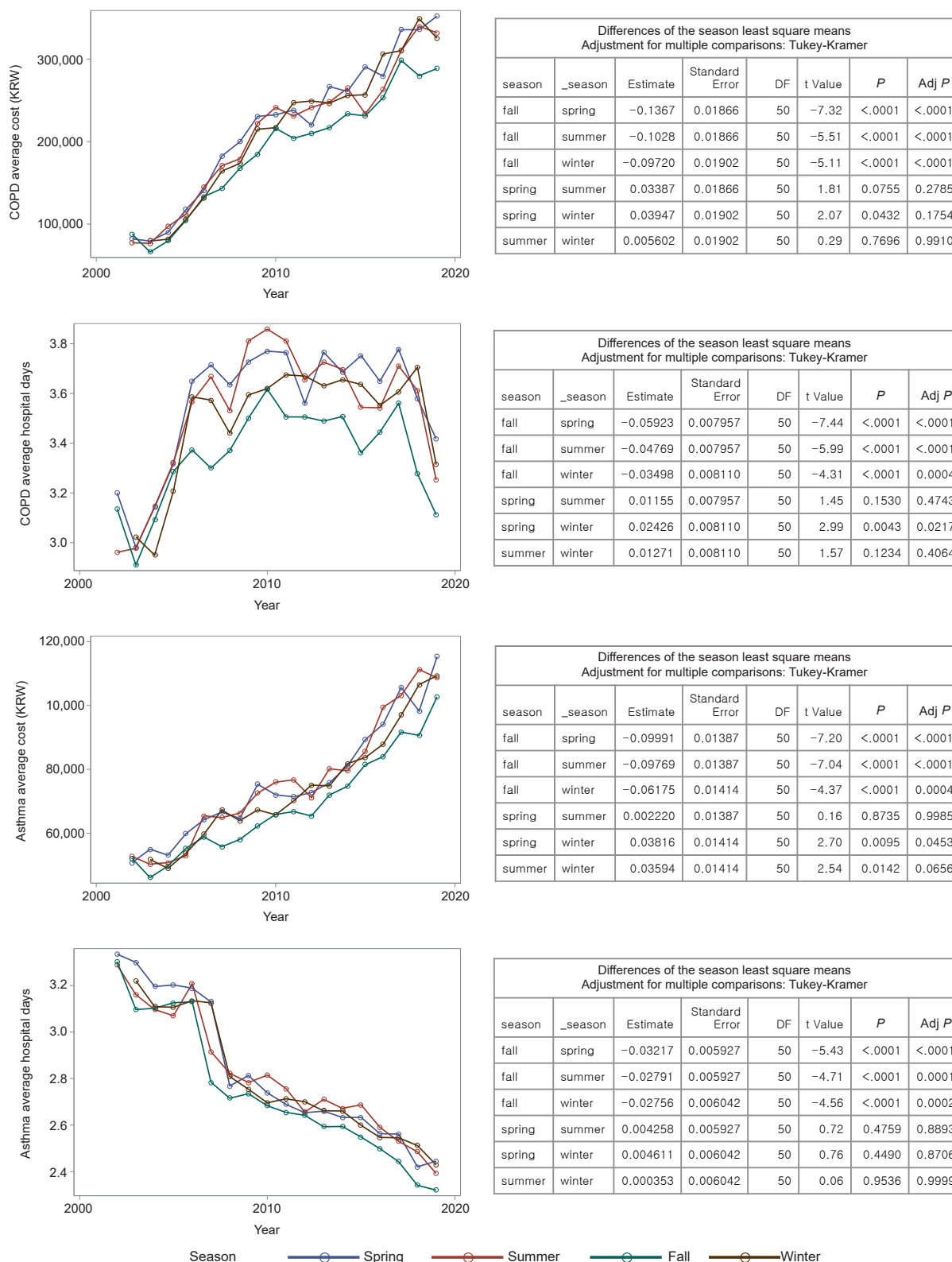


Fig. 2. The graphs of the seasonal average cost and hospital days of COPD and asthma (Left) and the results of GLIMMIX analysis among seasons (Right). Adj *P*, adjusted *P*-value; COPD, chronic obstructive pulmonary disease; DF, degree of freedom; GLIMMIX, generalized linear mixed model.

Table 2. Pearson correlation coefficient & Spearman correlation coefficient of the each variables

	Pearson correlation coefficient				Spearman's rank correlation coefficient			
	Chronic obstructive pulmonary disease		Asthma		Chronic obstructive pulmonary disease		Asthma	
	avg_cost	avg_adm	avg_cost	avg_adm	avg_cost	avg_adm	avg_cost	avg_adm
avg_age	0.97271 <0.0001 71	0.56515 <0.0001 71	0.95886 <0.0001 71	-0.94957 <0.0001 71	0.97126 <0.0001 71	0.41881 0.0003 71	0.96697 <0.0001 71	-0.95547 <0.0001 71
temperature	-0.028 0.8167 71	0.00751 0.9504 71	0.04155 0.7308 71	0.00201 0.9867 71	0.0083 0.9452 71	-0.05124 0.6713 71	0.07502 0.5341 71	-0.08154 0.499 71
temp_range	0.649 0.5907 71	0.01713 0.8872 71	0.05327 0.659 71	-0.00782 0.9484 71	0.03252 0.7878 71	0.00275 0.9818 71	-0.00646 0.9574 71	-0.01196 0.9212 71
wind	-0.06069 0.6151 71	0.26393 0.0261 71	-0.15096 0.2089 71	0.22788 0.056 71	-0.05113 0.6719 71	0.34264 0.0034 71	-0.1132 0.3473 71	0.25379 0.0327 71
rainfall	-0.13396 0.2654 71	-0.04424 0.7141 71	-0.07966 0.509 71	0.13646 0.2565 71	-0.08905 0.4602 71	-0.00629 0.9585 71	-0.03377 0.7798 71	0.06742 0.5764 71
humidity	-0.04536 0.7072 71	-0.08341 0.4892 71	-0.00302 0.98 71	-0.08065 0.5038 71	-0.05029 0.6771 71	-0.08354 0.4886 71	0.01758 0.8843 71	-0.04848 0.6881 71
PM2.5	0.25072 0.3005 19	0.43753 0.061 19	0.00675 0.9781 19	0.3535 0.1376 19	0.23782 0.3269 19	0.37034 0.1186 19	0.0079 0.9744 19	0.33699 0.1583 19
PM10	-0.01436 0.9309 39	0.44388 0.0046 39	-0.18813 0.2514 39	0.31154 0.0535 39	-0.01448 0.9303 39	0.45801 0.0045 39	-0.21433 0.1901 39	0.33399 0.0377 39

The first line is for correlation coefficient, the second line is for *P*-value, and the third line is for the number of variables included in analysis.

tion with the wind speed and PM10 ($P < 0.05$). Other factors had no statistically significant correlation, but PM2.5 had a positive correlation with low *P*-value (0.0610 for Pearson correlation coefficient, 0.1186 for Spearman's rank correlation coefficient).

For asthma, the number of hospital days had a positive correlation with wind speed and PM10. For Pearson correlation coefficient, *P*-value was 0.0560 and 0.0535, respectively. For Spearman's rank correlation coefficient, *P*-value was 0.0327 and 0.0377, respectively.

Since we see the strong relationship of the age with cost and the number of hospital days, the age was always controlled through all analysis. Also, since we have less data, PM10 and PM2.5 were analyzed separately with other variables. We grouped independent variables into rainfall and humidity, temperature, temperature range and wind speed, and all independent variables together for multiple regression. Each multiple regression analysis was done and Table 3 is the result.

For COPD (Table 3), PM2.5, PM10, temperature, and daily temperature range was not statistically associated with the cost.

The wind speed ($P = 0.0032$) and humidity ($P = 0.0078$) had statistically significant relationship with the cost when analyzed separately. Average hospital days were not statistically associated with PM2.5, PM10, temperature, daily temperature range, but had a relationship with the wind speed ($P = 0.0008$), rainfall, and humidity ($P = 0.0006$). For the hospital days, less strong relationship was shown with the age, and the age had a negative correlation with the hospital days.

For asthma (Table 4), PM2.5, PM10, temperature, and daily temperature range had no significant relationship with the cost. Humidity had a negative correlation ($P < 0.05$), and the rainfall and wind might have positive correlation when analyzed separately. Average hospital days were not statistically associated with daily temperature range, rainfall, PM2.5 and PM10. However, humidity had a negative correlation ($P < 0.05$), and temperature had a positive correlation ($P < 0.05$). Wind speed might have positive correlation. Similar with COPD hospital days, the age had a negative correlation with the hospital days.

Table 5 shows the results of GAMM analysis. We did not in-

Table 3. Multiple regression analysis of COPD

Variable	The seasonal average cost of COPD			The seasonal average hospital days of COPD		
	Parameter estimate	Standard error	P	Parameter estimate	Standard error	P
Intercept	-314,224	574,389	<0.0001	9.71238	4.43566	0.0448
copd_avg_age	46,273	7,816.6251	<0.0001	-0.08981	0.06036	0.1575
PM2.5	1,752.265	2,624.4385	0.5145	0.0001956	0.02027	0.9924
PM10	82.41673	1,319.175	0.951	0.0085	0.01019	0.3985
Intercept	-2,049,009	581,534	0.0031	20.36367	4.13265	0.0002
copd_avg_age	34,735	7,468.6316	0.0003	-0.20326	0.05308	0.0016
rainfall	87.2336	47.18053	0.0843	0.00108	0.0003353	0.0057
humidity	-3,338.158	1,087.4547	0.0078	-0.033	0.00773	0.0006
Intercept	-3,241,653	465,989	<0.0001	8.61624	3.3875	0.0234
copd_avg_age	46,494	6,355.324	<0.0001	-0.0898	0.0462	0.0721
temperature	260.20429	573.44326	0.657	0.00817	0.00417	0.0703
temp_range	-4,666.071	3,849.1832	0.2455	-0.01278	0.02798	0.6549
wind	92,555	26,025	0.0032	0.80418	0.18919	0.0008
Intercept	-2,165,939	838,465	0.0273	15.44122	6.62951	0.0421
copd_avg_age	37,466	9,818.8209	0.0034	-0.14795	0.07763	0.0858
temperature	1,019.2853	1,157.6661	0.3993	0.01346	0.00915	0.1721
temp_range	-9,270.478	8,716.8756	0.3126	-0.03566	0.06892	0.6161
wind	79,830	43,175	0.0942	0.44828	0.34137	0.2185
rainfall	-7.18028	76.04747	0.9266	0.0003419	0.0006013	0.5822
humidity	-3,779.849	2,168.2943	0.1119	-0.02591	0.01714	0.1617
PM2.5	-3,833.308	4,374.7131	0.4015	-0.00207	0.03459	0.9536
PM10	10.40406	2,294.8818	0.9965	-0.000547	0.01814	0.9766

COPD, chronic obstructive pulmonary disease.

Table 4. Multiple regression analysis of asthma

Variable	The seasonal average cost of asthma			The seasonal average hospital days of asthma		
	Parameter estimate	Standard error	P	Parameter estimate	Standard error	P
Intercept	-557,587	96,234	<0.0001	7.44705	1.11301	<0.0001
asthma_avg_age	9,129.176	1,337.8324	<0.0001	-0.07129	0.01547	0.0003
PM2.5	378.5073	661.51246	0.5757	0.00749	0.00765	0.3432
PM10	-44.08133	331.96245	0.8961	-0.00156	0.00384	0.69
Intercept	-395,094	98,466	0.0011	9.49835	1.17798	<0.0001
asthma_avg_age	7,510.0978	1,281.6409	<0.0001	-0.09177	0.01533	<0.0001
rainfall	25.75974	12.46232	0.0564	0.0003168	0.0001491	0.0506
humidity	-708.1199	275.299	0.0212	-0.00853	0.00329	0.0205
Intercept	-591,373	87,396	<0.0001	6.80214	0.76297	<0.0001
asthma_avg_age	9,287.8104	1,210.341	<0.0001	-0.06715	0.01057	<0.0001
temperature	264.75869	164.98158	0.1309	0.00425	0.00144	0.0106
temp_range	-771.0006	1,098.7398	0.4944	-0.01884	0.00959	0.0697
wind	18,152	7,571.3322	0.031	0.31966	0.0661	0.0003
Intercept	-287,649	127,563	0.0478	7.92584	1.0088	<0.0001
asthma_avg_age	7,214.8766	1,393.2096	0.0004	-0.06987	0.01102	<0.0001
temperature	901.45931	245.871	0.0043	0.01159	0.00194	0.0001
temp_range	-1,805.899	1,823.5352	0.3454	-0.03376	0.01442	0.0413
wind	-5,175.28	9,229.5748	0.5873	0.14898	0.07299	0.0685
rainfall	8.56444	16.19724	0.6085	-9.47E-05	0.0001281	0.4767
humidity	-1,612.611	460.03165	0.0057	-0.00916	0.00364	0.0305
PM2.5	526.66773	919.57584	0.5795	0.00621	0.00727	0.4132
PM10	-380.7762	485.79071	0.4513	-0.00129	0.00384	0.7433

clude PM10 and PM2.5 in analysis because data size was too small to analyze. Variable year is included as the random effect. To avoid overfitting, we limited degrees of freedom to 2, which can explain U shape model or inverted U shape model. Age and temperature range were assumed to have a linear association rather than a U-shaped or inverted U-shaped relationship. Therefore, spline was not applied to these variables to avoid overfitting.

As a result for COPD, the temperature was the only factor associated with the average cost of COPD except age. Average hospital days had a correlation with wind speed and temperature. For asthma, only temperature had a correlation with average cost, and wind speed and temperature had a correlation with

average hospital days. However, this GAMM analysis was little overfitted, which might be due to small data size or too many variables.

We analyzed the difference between male and female (Table 6). Average cost of COPD was not statistically different, although mean cost was higher in male. Average cost of asthma was statistically different ($P=0.0184$), and the cost for female was higher. The hospital days of COPD was statistically different ($P=0.0007$), and female had a higher value. On the other hand, the hospital days of asthma was not statistically different, and the mean value was slightly higher in male.

Table 5. GAMM analysis of COPD and asthma

The seasonal average cost of COPD			The seasonal average cost of asthma		
Effect	Num DF	P	Effect	Num DF	P
copd_avg_age	1	<0.0001	asthma_avg_age	1	<0.0001
spl_hum	2	0.8516	spl_hum	2	0.2391
spl_rain	2	0.2326	spl_rain	2	0.5845
spl_wind	2	0.2081	spl_wind	2	0.4651
spl_temp	2	0.0421	spl_temp	2	0.0046
temp_range	1	0.2503	temp_range	1	0.1892

The seasonal average hospital days of COPD			The seasonal average hospital days of asthma		
Effect	Num DF	P	Effect	Num DF	P
copd_avg_age	1	0.0012	asthma_avg_age	1	<0.0001
spl_hum	2	0.5233	spl_hum	2	0.3335
spl_rain	2	0.6744	spl_rain	2	0.6794
spl_wind	2	0.0103	spl_wind	2	0.0373
spl_temp	2	0.0267	spl_temp	2	0.0074
temp_range	1	0.5333	temp_range	1	0.132

spl_ means we analyzed giving spline effects to the variables followed by spl_. spl_hum means we gave the spline effect up to DF 2 for the variable humidity.

COPD, chronic obstructive pulmonary disease; DF, degree of freedom; GAMM, generalized additive mixed model.

Table 6. T-test for the seasonal average cost and hospital days of COPD and asthma between sex

The seasonal average cost of COPD				The seasonal average cost of asthma			
Sex	Number	Mean	Std Dev	Sex	Number	Mean	Std Dev
Female	71	208,786	107,445	Female	71	76,530.5	20,220
Male	71	212,577	73,903	Male	71	69,325.1	12,630.4
Method	Variances	DF	P	Method	Variances	DF	P
Pooled	Equal	140	0.8069	Pooled	Equal	140	0.0181
Satterthwaite	Unequal	124.12	0.8069	Satterthwaite	Unequal	111.56	0.0184

The seasonal average hospital days of COPD				The seasonal average hospital days of asthma			
Sex	Number	Mean	Std Dev	Sex	Number	Mean	Std Dev
Female	71	3.6907	0.5542	Female	71	2.7851	0.2746
Male	71	3.4358	0.2582	Male	71	2.7995	0.2899
Method	Variances	DF	P	Method	Variances	DF	P
Pooled	Equal	140	0.0006	Pooled	Equal	140	0.767
Satterthwaite	Unequal	99.03	0.0007	Satterthwaite	Unequal	139.59	0.767

COPD, chronic obstructive pulmonary disease; DF, degree of freedom; Std Dev, standard deviation.

Table 7. The result of GLIMMIX analysis for total seasonal values among seasons

Total seasonal number of the patients of COPD				Total seasonal number of the patients of asthma			
Season	_Season	Estimate	Adj P	Season	_Season	Estimate	Adj P
Fall	Spring	-513.06	<0.0001	Fall	Spring	-3,096.83	<0.0001
Fall	Summer	379.39	0.0004	Fall	Summer	2,577.56	<0.0001
Fall	Winter	-277.39	0.014	Fall	Winter	-2,921.56	<0.0001
Spring	Summer	892.44	<0.0001	Spring	Summer	5,674.39	<0.0001
Spring	Winter	235.67	0.0476	Spring	Winter	175.28	0.9847
Summer	Winter	-656.78	<0.0001	Summer	Winter	-5,499.11	<0.0001
Total seasonal medical cost of COPD				Total seasonal medical cost of asthma			
Season	_Season	Estimate	Adj P	Season	_Season	Estimate	Adj P
Fall	Spring	-0.2212	<0.0001	Fall	Spring	-0.2688	<0.0001
Fall	Summer	-0.06132	0.0514	Fall	Summer	0.04777	0.2126
Fall	Winter	-0.164	<0.0001	Fall	Winter	-0.231	<0.0001
Spring	Summer	0.1599	<0.0001	Spring	Summer	0.3135	<0.0001
Spring	Winter	0.05727	0.077	Spring	Winter	0.03473	0.4638
Summer	Winter	-0.1026	0.0003	Summer	Winter	-0.2788	<0.0001
Total seasonal hospital days of COPD				Total seasonal hospital days of asthma			
Season	_Season	Estimate	Adj P	Season	_Season	Estimate	Adj P
Fall	Spring	-0.1382	<0.0001	Fall	Spring	-0.1887	<0.0001
Fall	Summer	0.002888	0.997	Fall	Summer	0.1315	<0.0001
Fall	Winter	-0.08123	<0.0001	Fall	Winter	-0.17	<0.0001
Spring	Summer	0.141	<0.0001	Spring	Summer	0.3202	<0.0001
Spring	Winter	0.05698	0.0008	Spring	Winter	0.01865	0.8243
Summer	Winter	-0.08403	<0.0001	Summer	Winter	-0.3016	<0.0001

Differences of the season least square means. Adjustment for multiple comparisons: Tukey-Kramer.

Adj P, adjusted P-value; COPD, chronic obstructive pulmonary disease; GLIMMIX, generalized linear mixed model.

DISCUSSION

From the results, we could see the seasonal difference of the cost and hospital days of COPD and asthma. Furthermore, we could analyze the association with the meteorological factors and the cost and hospital days of COPD and asthma.

The known exacerbation factors for COPD include low temperature, drastic temperature variability, extreme humidity, air pollution, or other seasonal respiratory infection. For asthma, low temperature, high humidity, high daily temperature range, air pollution, and allergen factors can cause exacerbation.

In Korea, fall and winter are usually considered more vulnerable to exacerbation of COPD and asthma. However from our analysis, the average cost and hospital days of COPD and asthma were lowest in the fall, and often high in spring. We further analyzed the total seasonal number of the patients, the total seasonal medical cost, and the total seasonal hospital days for COPD and asthma patients (Table 7). The results were similar and the analysis of the difference among seasons are done by GLIMMIX method. The spring and winter had more number of patients, more cost burden, and more hospital days than the fall and summer ($P<0.05$). Since the number of patients of COPD and asthma

were more in fall than in summer ($P<0.05$), fall was the least burdensome season.

In Fig. 1, we could see the graph of rainfall, temperature, daily temperature range, and humidity of fall is in the middle, which means the weather is usually not extreme. Also, wind speed, PM 2.5, and PM 10 are low in fall. Wind can spread allergens and air pollutants [23], and may also cause inhalation of cold, dry, or excessively humid air. Thus, low wind speed, PM 2.5, PM 10 has low possibility for exacerbation. Another possible explanation is that people use air conditioners and heaters less frequently in fall, which may result in better respiratory health.

Another interesting finding was that the number of hospital days for asthma showed a downward trend, whereas that for COPD exhibited an inverted U-shaped like pattern, not exactly a right-upward linear pattern. We analyzed a cohort database, therefore, participants naturally became older over time and more susceptible to COPD and asthma, which may have contributed to the upward trend in hospital days. This trend might be explained by survivor bias, changing both slopes to downward trend. Although the average hospital days decreased, the average cost had increased. It suggests that more examinations and intensive treatments were given to older patients who may have more

comorbidities, and inflation was also a contributing factor. There should be more research about the reason why the survivor bias influence in asthma earlier than in COPD for seniors.

Wind speed and humidity might have rather stronger association with COPD than other meteorological factors. For asthma, wind speed, temperature and humidity might have stronger association than other factors. The results suggest old patients with COPD and asthma should avoid dry condition, strong wind, and hot temperature. Previous studies suggested that the extreme humidity and temperature can cause more exacerbation, and it may suggest that Korea is not the country with extremely high humidity and extremely low temperature.

With Spearman's rank correlation coefficient from Table 2 and Table 5, in the view point of non-linear association of variables, temperature and wind speed could be the only factors associated with the average cost and hospital days of COPD and asthma. Our results indicate that temperature is associated with both the average cost and hospital days for COPD and asthma, consistent with findings from previous studies. Also, according to the previous studies, extreme wind speed is associated with average hospital days of COPD and asthma. High wind speed can carry air pollutants into the respiratory system and stimulate mucous membrane, thereby exacerbating COPD and asthma. Low wind speed can trap air pollutants and deteriorate air circulation, thereby exacerbating COPD and asthma.

More males are prone to have COPD, but the average cost burden of COPD was not significantly different between sex and the average number of hospital days was higher in female. The previous study in Europe, the severity of symptoms related with COPD was similar with sex, but the female has slow tendency to respond to the treatment [24]. In asthma, the female has a higher average cost burden, whereas the average number of hospital days is similar between males and females. The systematic review reported that the treatment for asthma was generally less effective in women, and 44% (the opposite was 17%) of evidence reported that the male responded better than the female to the treatment, whereas this percentage was 28% (the opposite was 26%) in COPD [25]. Especially ICS treatment for asthma responded significantly better for men. Also, female hormones trigger respiratory inflammation and allergic reactions, on the other hand, male hormones often play opposite role [26].

Limitation & strength

During analysis, we found difficulty with analyzing the meteorological factors with COPD and asthma. There were numerous

different ways to evaluate meteorological factors. Some studies used average temperatures of 3 days before visiting emergency department due to COPD, or daily temperature change of the day before the admission due to COPD. Meteorological factors are analyzed by various ways, and in Korea, seasonal meteorological variation is relatively distinct and we seemed that analysis with seasonal time interval would be meaningful to know the results.

We used patients' data from NHIS, and meteorological data from KMA and KOSIS. The data from KMA and NHIS had different regional border, therefore it was hard to analyze with more specific regional meteorological factors. It may be possible for some regions, since KMA system has the meteorological data of Seoul plus Gyeonggi plus Incheon, or Daegu plus Gyeongbuk. However, some regions like Gangwon, KMA suggest that climate is different among left and right area of Taebaek mountains and Taebaek mountains, therefore, it does not provide exact data of total Gangwon's climate. Instead, it provides the data of Gangwon Yeongdong and Gangwon Yeongseo. It is possible to analyze in more specific regions if we only include the patients of COPD and asthma in smaller regions, for example, Seoul and Gyeonggi or only Seoul.

As a strength of our study, few previous studies have included various meteorological variables in Korea. By analyzing these variables together, we could estimate the effect of variables minimizing the correlation of each variables.

Many studies used the visit number of emergency departments or hospitals to evaluate the exacerbation of COPD and asthma. It would be difficult to include the severity of hospital visit. Our study, on the other hand, evaluated the expense of medical cost and the number of hospital days, which can reflect the severity of diseases more.

We analyzed data from 2002 to 2019 with seasonal variation, which showed the trend of relatively long period. Thus, our analysis may show general correlation of the medical burden of COPD and asthma with meteorological and seasonal factors.

Conclusion

The analysis showed that the severity of COPD and asthma in the point of the cost burden and the number of hospital days seems lowest in fall. For other seasons, the details differ, but winter seems to be the second least burdensome season. Spring and summer are thought to be a good weather with the chronic respiratory diseases, however, according to our analysis, people with COPD and asthma should care about their respiratory

health also in spring and summer. For meteorological factors in Korea, we suggest that patients with COPD and asthma should avoid extreme temperature, dry environment and strong wind for their respiratory health.

ORCID

Taehoon LEE, <https://orcid.org/0009-0001-7473-8046>

Hayoung SHIM, <https://orcid.org/0000-0002-5127-2829>

Belong CHO, <https://orcid.org/0000-0001-9558-689X>

AUTHOR CONTRIBUTIONS

Dr. Belong CHO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: TL and BC. Data curation: TL and BC. Formal analysis: TL and BC. Methodology: TL and BC. Software: TL and HS. Writing—original draft: TL. Writing—review & editing: TL and BC.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

FUNDING

None.

DATA AVAILABILITY

The data presented in this study are available upon reasonable request from the first author and corresponding author. The meteorological data are available in KMA and KOSIS for free, and the data about the seasonal medical cost and the hospital days are from NHIS - Senior cohort database 2.0 with data fee.

REFERENCES

- Kim C, Yoo KH, Rhee CK, Yoon HK, Kim YS, Lee SW, et al. Health care use and economic burden of patients with diagnosed chronic obstructive pulmonary disease in Korea. *Int J Tuberc Lung Dis* 2014;18(6):737-43.
- An TJ, Yoon HK. Prevalence and socioeconomic burden of chronic obstructive pulmonary disease. *J Korean Med Assoc* 2018;61(9):533-8.
- Bahadori K, Doyle-Waters MM, Marra C, Lynd L, Alasaly K, Swiston J, et al. Economic burden of asthma: a systematic review. *BMC Pulm Med* 2009;9:24.
- Park YS, Park S, Lee CH. The attributable risk of smoking on all-cause mortality in Korean: a study using KNHANES IV-VI (2007-2015) with mortality data. *Tuberc Respir Dis (Seoul)* 2020;83(4):268-75.
- Kim Y, Park TS, Kim TH, Rhee CK, Kim C, Lee JS, et al. Impact of previous occupational exposure on outcomes of chronic obstructive pulmonary disease. *J Pers Med* 2022;12(10):1592.
- Guo C, Zhang Z, Lau AKH, Lin CQ, Chuang YC, Chan J, et al. Effect of long-term exposure to fine particulate matter on lung function decline and risk of chronic obstructive pulmonary disease in Taiwan: a longitudinal, cohort study. *Lancet Planet Health* 2018;2(3):e114-25.
- Lee J, Jung HM, Kim SK, Yoo KH, Jung KS, Lee SH, et al. Factors associated with chronic obstructive pulmonary disease exacerbation, based on big data analysis. *Sci Rep* 2019;9(1):6679.
- Lee YS, Oh JY, Min KH, Lee SY, Kang KH, Shim JJ. The association between living below the relative poverty line and the prevalence of chronic obstructive pulmonary disease. *J Thorac Dis* 2019;11(2):427-37.
- Wiesch DG, Meyers DA, Bleecker ER. Genetics of asthma. *J Allergy Clin Immunol* 1999;104(5):895-901.
- Rönmark E, Andersson C, Nyström L, Forsberg B, Järvholm B, Lundbäck B. Obesity increases the risk of incident asthma among adults. *Eur Respir J* 2005;25(2):282-8.
- Chowdhury NU, Guntur VP, Newcomb DC, Wechsler ME. Sex and gender in asthma. *Eur Respir Rev* 2021;30(162):210067.
- Gaffin JM, Phipatanakul W. The role of indoor allergens in the development of asthma. *Curr Opin Allergy Clin Immunol* 2009;9(2):128-35.
- Edwards MR, Bartlett NW, Hussell T, Openshaw P, Johnston SL. The microbiology of asthma. *Nat Rev Microbiol* 2012;10(7):459-71.
- Jacquemin B, Schikowski T, Carsin AE, Hansell A, Krämer U, Sunyer J, et al. The role of air pollution in adult-onset asthma: a review of the current evidence. *Semin Respir Crit Care Med* 2012;33(6):606-19.
- Young MT, Sandler DP, DeRoo LA, Vedal S, Kaufman JD, London SJ. Ambient air pollution exposure and incident adult asthma in a nationwide cohort of U.S. women. *Am J Respir Crit*

- Care Med 2014;190(8):914-21.
16. Cho B, Choi J, Yum Y. Air pollution and hospital admissions for respiratory disease in certain areas of Korea. *J Occup Health* 2000;42(4):185-91.
 17. Anderson GB, Dominici F, Wang Y, McCormack MC, Bell ML, Peng RD. Heat-related emergency hospitalizations for respiratory diseases in the Medicare population. *Am J Respir Crit Care Med* 2013;187(10):1098-103.
 18. Xu Q, Zhou Q, Chen J, Li T, Ma J, Du R, et al. The incidence of asthma attributable to temperature variability: an ecological study based on 1990-2019 GBD data. *Sci Total Environ* 2023;904:166726.
 19. Shi C, Zhu J, Wu Q, Liu Y, Hao Y. Effects of ambient temperature and humidity on COPD mortality in Ganzhou city, China. *Int J Biometeorol* 2024;68(9):1789-98.
 20. Makrufardi F, Manullang A, Rusmawatiningsih D, Chung KE, Lin SC, Chuang HC. Extreme weather and asthma: a systematic review and meta-analysis. *Eur Respir Rev* 2023;32(168):230019.
 21. Atkinson RW, Carey IM, Kent AJ, van Staa TP, Anderson HR, Cook DG. Long-term exposure to outdoor air pollution and the incidence of chronic obstructive pulmonary disease in a national English cohort. *Occup Environ Med* 2015;72(1):42-8.
 22. Zhang Y, Yang X, Jiang W, Gao X, Yang B, Feng XL, et al. Short-term effects of air pollutants on hospital admissions for asthma among older adults: a multi-city time series study in Southwest, China. *Front Public Health* 2024;12:1346914.
 23. Silva Monte K, Costa AC, Morais HCC, Gomes Guedes N, da Beatriz CBC, Cruz Neto J, et al. Decreased childhood asthma hospitalizations linked to hotter, drier climate with lower wind speed in drylands. *Int J Environ Health Res* 2025;35(9):2596-608.
 24. Watson L, Schouten JP, Löfdahl CG, Pride NB, Laitinen LA, Postma DS; European Respiratory Society Study on Chronic Obstructive Pulmonary Disease. Predictors of COPD symptoms: does the sex of the patient matter? *Eur Respir J* 2006;28(2):311-8.
 25. Rogliani P, Cavalli F, Ritondo BL, Cazzola M, Calzetta L. Sex differences in adult asthma and COPD therapy: a systematic review. *Respir Res* 2022;23(1):222.
 26. Fuentes N, Silveyra P. Endocrine regulation of lung disease and inflammation. *Exp Biol Med (Maywood)* 2018;243(17-18):1313-22.

Association of the Arachidonic Acid-to-Eicosapentaenoic Acid Ratio with Metabolic Dysfunction-Associated Steatotic Liver Disease and the Fibrosis-4 Index in Korean Adult Health Check-up Examinees: A Single-Center Cross-Sectional Study

Sung-Jae JANG, MD¹ and Bo-Kyung SHINE, MD, PhD^{1,2}

¹Department of Family Medicine, Dong-A University Hospital, Busan, Korea

²Department of Family Medicine, Dong-A University College of Medicine, Busan, Korea

ABSTRACT

Background: The arachidonic acid-to-eicosapentaenoic acid (AA/EPA) ratio reflects the balance between omega-6 and omega-3 fatty acid pathways and has been discussed as a marker of inflammatory and cardiometabolic status. However, its association with metabolic dysfunction-associated steatotic liver disease (MASLD) and the fibrosis-4 (FIB-4) index remains unclear. This study investigated whether AA/EPA is associated with MASLD status and FIB-4 in Korean adult health check-up examinees.

Methods: This single-center cross-sectional study included 392 adult health check-up examinees who underwent abdominal ultrasonography and red blood cell fatty acid testing. MASLD was defined as hepatic steatosis on ultrasonography with at least one cardiometabolic risk factor. FIB-4 was calculated from age, aspartate aminotransferase, alanine aminotransferase, and platelet count. Associations of AA/EPA with MASLD and FIB-4 were evaluated using logistic and linear regression analyses.

Results: Among 392 participants, 203 (51.8%) met MASLD criteria. AA/EPA was not associated with MASLD after multivariable adjustment (adjusted odds ratio [OR], 1.02; 95% confidence interval [CI], 0.98–1.06). In contrast, AA/EPA was inversely associated with continuous FIB-4 after adjustment for cardiometabolic covariates, with chronological age excluded to avoid mathematical overlap with the FIB-4 equation (adjusted β = -0.02; 95% CI, -0.03 to -0.01). In exploratory component analyses, AA/EPA was not significantly correlated with aspartate aminotransferase or alanine aminotransferase, whereas it was positively correlated with platelet count.

Conclusions: AA/EPA was not associated with MASLD status, whereas it was inversely associated with FIB-4. Category-based analyses supported the direction of this association, and component analyses suggested that platelet-related variation may partly contribute to the FIB-4 finding. These results do not support AA/EPA as a simple MASLD screening marker. Further studies incorporating direct fibrosis assessment, platelet-related parameters, and detailed dietary or supplement information are needed.

Keywords: Arachidonic acid, Eicosapentaenoic acid, Non-alcoholic fatty liver disease, Fatty liver, Fibrosis, Platelet count

Received: June 23, 2026; **Revised:** July 3, 2026; **Accepted:** July 7, 2026

Corresponding author: Bo-Kyung SHINE, MD, PhD

Department of Family Medicine, Dong-A University Hospital, Dong-A University College of Medicine, 26 Daesingongwon-ro, Seo-gu, Busan 49201, Korea
Tel: +82-51-240-5290 Fax: +82-51-248-1510 E-mail: kdwsbk@naver.com

INTRODUCTION

Metabolic dysfunction-associated steatotic liver disease (MASLD) is one of the most common causes of chronic liver disease worldwide and is closely associated with obesity, insulin resistance, dyslipidemia, type 2 diabetes, and cardiovascular disease [1-6]. The conceptual shift from nonalcoholic fatty liver disease (NAFLD) to MASLD reflects the increasing emphasis on the metabolic context of steatotic liver disease [1,5,6]. Because MASLD includes individuals with diverse metabolic profiles and prognostic trajectories, additional markers that may help refine risk stratification remain clinically relevant.

Although hepatic steatosis is common, prognosis in fatty liver disease is driven more strongly by fibrosis than by steatosis alone [7,8]. Previous longitudinal studies and meta-analyses have shown that fibrosis stage is the strongest predictor of liver-related and overall mortality in NAFLD [7,8]. Therefore, identifying individuals at risk for advanced fibrosis is an important clinical objective in patients with MASLD.

The fibrosis-4 (FIB-4) index is a widely used noninvasive index for fibrosis risk stratification because it is simple, inexpensive, and based on routinely available variables, including age, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and platelet count [9]. Current clinical practice guidelines support the use of FIB-4 as a first-line tool in MASLD pathways [10]. However, FIB-4 is a surrogate index rather than a direct measure of liver fibrosis, and its interpretation can vary according to age and clinical setting [11,12].

Fatty acid composition has also been studied as a potential marker of cardiometabolic and inflammatory risk [13,14]. Arachidonic acid (AA) is an omega-6 polyunsaturated fatty acid (PUFA) and a precursor of eicosanoids involved in inflammatory and thrombotic pathways. Eicosapentaenoic acid (EPA) is an omega-3 PUFA that competes with AA in related enzymatic pathways and is generally linked to less inflammatory or pro-resolving lipid mediators [14,15]. Therefore, the AA/EPA ratio may reflect the balance between omega-6 and omega-3 fatty acid pathways and has been discussed as a marker of inflammatory and cardiometabolic status [13-15].

Previous studies have suggested that the balance between EPA and AA may be related to fatty liver disease and cardiometabolic risk. In a previous study of patients with NAFLD, a lower EPA/AA ratio was proposed as a possible link between NAFLD and cardiovascular disease [16]. Because the AA/EPA ratio used in the present study represents the reciprocal direction of the EPA/

AA ratio, a higher AA/EPA ratio may reflect a fatty acid profile relatively shifted toward AA rather than EPA. Biologically, this imbalance may be relevant because AA and EPA compete in lipid mediator pathways involved in inflammation, oxidative stress, thrombosis, and platelet activity [14-18]. These pathways have also been implicated in metabolic liver disease progression and fibrosis-related risk [17,18]. However, evidence from health check-up cohorts directly comparing individuals with and without MASLD remains limited. In addition, few studies have evaluated whether AA/EPA is associated with formula-based fibrosis risk indices such as FIB-4.

Therefore, this study aimed to investigate whether the AA/EPA ratio is associated with MASLD status and FIB-4 in Korean adult health check-up examinees. Because FIB-4 is calculated from age, AST, ALT, and platelet count, we also explored whether individual components of FIB-4 contributed to the observed association between AA/EPA and FIB-4 [9].

METHODS

Study design and setting

This was a single-center cross-sectional study conducted using data from the Health Promotion Center of Dong-A University Hospital, Busan, Republic of Korea. We reviewed adult health check-up examinees between August 2021 and December 2025 who had available fatty acid fraction measurements including AA and EPA.

Study population

A total of 575 health check-up participants were initially screened. Eligible participants were adults aged 19 years or older who underwent comprehensive health check-ups during the study period, had available AA and EPA measurements, underwent abdominal ultrasonography, and had sufficient clinical and laboratory data for the planned analyses.

Participants were excluded according to prespecified criteria, including heavy alcohol consumption (≥ 30 g/day in males or ≥ 20 g/day in females), high-dose omega-3 supplementation (approximately $\geq 1,000$ mg/day), viral hepatitis, autoimmune liver disease, or other chronic liver diseases, liver cirrhosis or hepatocellular carcinoma, medication exposure considered likely to materially affect hepatic steatosis or aminotransferase levels, and missing key variables required for the analyses. Medications considered relevant included amiodarone, methotrexate, tamoxifen, valproic acid, systemic corticosteroids, antiretroviral therapy, ur-

sodeoxycholic acid, and biphenyl dimethyl dicarboxylate. Some participants met more than one exclusion criterion. After these exclusions, 392 participants were included in the final analytic sample.

Ethics

This study was performed in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of Dong-A University Hospital (IRB approval No. DAUHIRB-26-021; February 4, 2026). The requirement for informed consent was waived by the IRB because this study used retrospectively collected health check-up data.

Fatty acid measurements

Fatty acid fraction testing was performed by OmegaQuant Asia using the HS-Omega-3 Index test, which measures red blood cell membrane fatty acid composition by gas chromatography [13,19]. The AA/EPA ratio was analyzed as a continuous variable per 1-unit increase.

Metabolic dysfunction-associated steatotic liver disease definition and fibrosis assessment

MASLD was defined as hepatic steatosis detected by abdominal ultrasonography in the presence of at least one cardiometabolic risk factor, according to the current MASLD diagnostic framework [1]. In this cohort, cardiometabolic risk factors were operationalized as follows: body mass index ≥ 23 kg/m² or increased waist circumference, defined as ≥ 90 cm in males and ≥ 85 cm in females using Korean cutoffs; impaired fasting glucose or diabetes mellitus, defined as fasting glucose ≥ 100 mg/dL, hemoglobin A1c $\geq 5.7\%$, type 2 diabetes, or treatment for type 2 diabetes; elevated blood pressure, defined as blood pressure $\geq 130/85$ mmHg or antihypertensive treatment; and lipid-related cardiometabolic criteria, defined as triglycerides ≥ 150 mg/dL, high-density lipoprotein cholesterol ≤ 40 mg/dL in males or ≤ 50 mg/dL in females, or lipid-lowering treatment.

Fibrosis-related risk was assessed using the FIB-4 index [9,10]. FIB-4 was calculated from age, AST, ALT, and platelet count using the following formula: $\text{FIB-4} = (\text{age} \times \text{AST}) / (\text{platelet count} \times \sqrt{\text{ALT}})$ [9].

Multivariable adjustment

Multivariable models were adjusted for clinically relevant variables, including sex, body mass index, smoking status, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension. In the

MASLD model, age was additionally included as a covariate. AST and ALT were further included in an additional model to account for liver enzyme levels.

In the primary FIB-4 model, chronological age was not included as an additional covariate to avoid mathematical overlap with the FIB-4 equation [9]. AST, ALT, and platelet count were also not included in the primary FIB-4 model, as they are constituent variables of FIB-4 [9]. Instead, an additional exploratory component-related model including AST, ALT, and platelet count was performed to evaluate whether the association between AA/EPA and FIB-4 was attenuated after accounting for the variables that constitute the index. Given the mathematical relationship between these variables and FIB-4, this model was interpreted as an exploratory component-related analysis rather than as an ordinary confounder-adjusted model.

Statistical analyses

Continuous variables are presented as mean $\pm$ standard deviation or median (interquartile range), depending on distribution, and categorical variables are presented as number (percentage). Between-group comparisons were performed using the Student's t-test or Mann-Whitney U-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate.

Associations between AA/EPA and MASLD were evaluated using logistic regression analysis and are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Associations between AA/EPA and FIB-4 were evaluated using linear regression analysis and are presented as β coefficients with 95% CIs. Prespecified age-stratified analyses were performed using the following age groups: <35 , 35–44, 45–54, 55–64, and ≥ 65 years. An interaction analysis was used to assess effect modification by age group. Exploratory correlation analyses were additionally performed between AA/EPA and AST, ALT, and platelet count to explore which FIB-4 components might contribute to the observed association. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

To clarify the clinical relevance of the association between AA/EPA and FIB-4, additional analyses were performed using conventional FIB-4 risk categories: low risk, <1.3 ; intermediate risk, 1.3–2.67; and high risk, ≥ 2.67 . AA/EPA distributions across these ordered FIB-4 categories were compared using the Kruskal-Wallis test, and the monotonic trend was assessed using Spearman correlation between AA/EPA and the ordinal FIB-4 category. Pairwise comparisons were performed using Wilcoxon

rank-sum tests with Holm adjustment for multiple comparisons.

To address the adequacy of sample size, post-hoc detectable effect size calculations were performed using a two-sided α level of 0.05 and 80% power. With 203 participants in the MASLD group and 189 participants in the non-MASLD group, the study had 80% power to detect a between-group standardized difference of approximately 0.28 or larger. For correlation analyses, the total sample size of 392 participants provided 80% power to detect a correlation coefficient of approximately $|r|=0.14$ or larger. In MASLD-stratified analyses, the subgroup sample sizes provided 80% power to detect correlation coefficients of approximately $|r|=0.20$ or larger. Therefore, very small between-group differences or subgroup-specific associations may not have been detected.

Analyses were performed using Python (pandas, scipy, and statsmodels).

RESULTS

Baseline characteristics

A total of 392 participants were included in the final analysis, of whom 203 (51.8%) met MASLD criteria. Baseline characteristics according to MASLD status are summarized in Table 1. Compared with participants without MASLD, those with MASLD were more often male and had higher body mass index, higher alcohol intake, and higher prevalences of smoking, diabetes mellitus, and hypertension. Liver enzyme levels were also higher in the MASLD group. The AA/EPA ratio did not differ significantly between participants without and with MASLD (median [IQR],

8.21 [5.78–13.80] vs. 8.99 [6.24–14.20]; $P=0.30$) (Fig. 1). The median FIB-4 index was lower in the MASLD group. Age did not differ significantly between groups, whereas platelet count was significantly higher in the MASLD group. Because FIB-4 is calculated from age, AST, ALT, and platelet count, the lower FIB-4 value in the MASLD group should be interpreted in the context of the composite nature of the index [9].

Association between arachidonic acid-to-eicosapentaenoic acid ratio and metabolic dysfunction-associated steatotic liver disease

The AA/EPA ratio did not differ significantly according to MASLD status and was not associated with MASLD in logistic regression analysis. In the unadjusted model, the OR for MASLD per 1-unit increase in AA/EPA was 1.01 (95% CI, 0.98–1.04). Results were materially unchanged after adjustment for age, sex, body mass index, smoking status, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension (adjusted OR, 1.02; 95% CI, 0.98–1.06) and after further adjustment for AST and ALT (adjusted OR, 1.02; 95% CI, 0.98–1.06). These findings were observed despite marked differences in metabolic characteristics between participants with and without MASLD (Table 2).

Association between arachidonic acid-to-eicosapentaenoic acid ratio and fibrosis-4

In contrast to the null association observed with MASLD status, the AA/EPA ratio showed a significant inverse association with the FIB-4 index. In unadjusted linear regression, AA/EPA was inversely associated with FIB-4 ($\beta=-0.02$; 95% CI, -0.03

Table 1. Baseline characteristics according to MASLD status

Variable	Overall (n=392)	No MASLD (n=189)	MASLD (n=203)	P-value
Age (yr)	57.56±10.76	58.03±11.17	57.13±10.37	0.41
Male sex	224 (57.1)	61 (32.3)	163 (80.3)	<0.001
BMI (kg/m ²)	24.48±3.50	22.65±2.81	26.19±3.21	<0.001
Current or ex-smoker	179 (45.7)	47 (24.9)	132 (65.0)	<0.001
Alcohol intake (g/day)	6.54±8.45	4.50±7.32	8.44±9.00	<0.001
Diabetes mellitus	60 (15.3)	19 (10.1)	41 (20.2)	<0.01
Hypertension	127 (32.4)	42 (22.2)	85 (41.9)	<0.001
Dyslipidemia	114 (29.1)	53 (28.0)	61 (30.0)	0.66
AA/EPA ratio	8.52 (5.98–14.00)	8.21 (5.78–13.80)	8.99 (6.24–14.20)	0.30
FIB-4 index	1.27 (1.00–1.76)	1.38 (1.06–1.84)	1.15 (0.94–1.55)	<0.001
AST (IU/L)	29.00 (24.00–36.00)	27.00 (23.00–34.00)	32.00 (26.00–38.00)	<0.001
ALT (IU/L)	25.00 (20.00–37.00)	22.00 (17.00–29.00)	31.00 (24.00–43.00)	<0.001
Platelet count (10 ³ /μL)	260.97±61.36	251.45±59.56	269.84±61.84	<0.01

Values are presented as mean±standard deviation, median (interquartile range), or number (%). P-values were calculated using the Student t-test, Mann-Whitney U-test, chi-square test, or Fisher exact test, as appropriate.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; FIB-4, fibrosis-4; MASLD, metabolic dysfunction-associated steatotic liver disease.

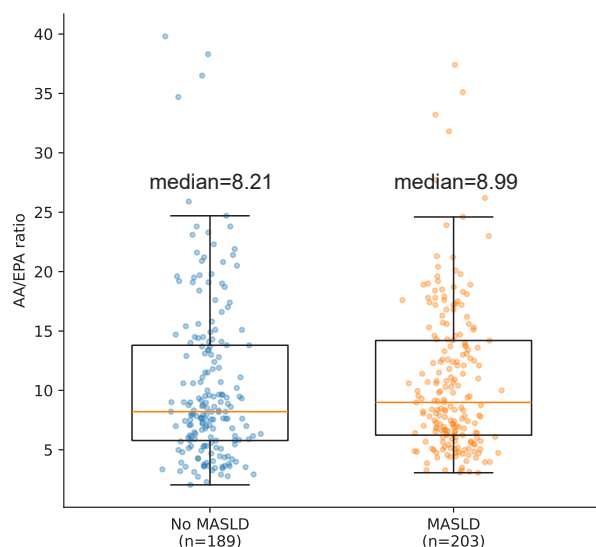


Fig. 1. Distribution of AA/EPA according to MASLD status. Box plots show the distribution of the AA/EPA ratio in participants with and without MASLD. Boxes indicate the median and interquartile range, whiskers indicate 1.5× the interquartile range, and individual points represent participants. Group differences were compared using the Mann-Whitney U-test.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; MASLD, metabolic dysfunction-associated steatotic liver disease.

to -0.01 ; $P<0.001$). This association remained significant after adjustment for sex, body mass index, smoking, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension; age was excluded to avoid mathematical overlap with the FIB-4 equation (adjusted $\beta=-0.02$; 95% CI, -0.03 to -0.01 ; $P<0.001$). In the exploratory component-related model additionally including AST, ALT, and platelet count, the association was attenuated; however, it remained statistically significant ($P<0.001$) (Table 3, Fig. 2). Given the mathematical relationship between these variables and FIB-4, this model should not be interpreted as an ordinary confounder-adjusted model [9].

When FIB-4 was categorized using conventional risk cut-offs, AA/EPA differed significantly across the low-risk (<1.3), intermediate-risk ($1.3-2.67$), and high-risk (≥ 2.67) groups. The median AA/EPA decreased from 9.99 (IQR, 7.10–15.70) in the low-risk group to 7.48 (IQR, 4.89–11.50) in the intermediate-risk group and 7.00 (IQR, 5.96–8.54) in the high-risk group ($P<0.001$). A significant inverse trend was observed across ordered FIB-4 categories (Spearman $\rho=-0.27$; $P<0.001$). In pairwise comparisons, AA/EPA was significantly lower in the intermediate- and high-risk groups than in the low-risk group,

Table 2. Association between AA/EPA and MASLD

Model	OR (95% CI) for AA/EPA	P-value
Model 0 (unadjusted)	1.01 (0.98–1.04)	0.60
Model 1 (adjusted) ^a	1.02 (0.98–1.06)	0.27
Model 2 (+AST/ALT) ^b	1.02 (0.98–1.06)	0.45

ORs with 95% CIs were calculated using logistic regression models.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; CI, confidence interval; MASLD, metabolic dysfunction-associated steatotic liver disease; OR, odds ratio.

^aAdjusted for age, sex, body mass index, smoking status, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension. ^bFurther adjusted for AST and ALT.

whereas no significant difference was observed between the intermediate- and high-risk groups (Supplementary Table 1).

Additional analyses

In MASLD-stratified analyses, the inverse association between AA/EPA and FIB-4 was observed both in participants without MASLD and in those with MASLD. In the fully adjusted model excluding age, the association remained significant in both the non-MASLD group ($\beta=-0.02$; 95% CI, -0.03 to -0.01 ; $P<0.01$) and the MASLD group ($\beta=-0.02$; 95% CI, -0.04 to -0.01 ; $P<0.01$) (Table 4, Fig. 3). Age-stratified analyses showed generally negative, although non-significant, estimates within individual age groups, with no significant interaction by age group (P for interaction=0.95) (Supplementary Table 2). In exploratory analyses of individual FIB-4 components, AA/EPA was not significantly correlated with AST or ALT, whereas it was positively correlated with platelet count ($r=0.18$; 95% CI, 0.08 to 0.27; $P<0.001$) (Table 5).

DISCUSSION

In this single-center cross-sectional study of Korean adult health check-up examinees, the principal finding was a discordant association of AA/EPA with MASLD status and FIB-4. AA/EPA was not associated with MASLD status, whereas it was inversely associated with the FIB-4 index. This association remained significant after multivariable adjustment and was also observed in analyses stratified by MASLD status.

The absence of a significant difference in AA/EPA according to MASLD status should be interpreted carefully. Although the univariate comparison did not show a significant difference between the MASLD and non-MASLD groups, multivariable logistic regression was clinically and methodologically relevant because the two groups differed substantially in sex distribu-

Table 3. Association between AA/EPA and FIB-4 index

Model	β (95% CI) for AA/EPA	P-value	R ²
Model 0 (unadjusted)	-0.02 (-0.03 to -0.01)	<0.001	0.05
Model 1 (adjusted; age excluded) ^a	-0.02 (-0.03 to -0.01)	<0.001	0.14
Model 2, exploratory component-related model (+AST/ALT/platelet count) ^b	-0.009 (-0.014 to -0.004)	<0.001	0.76

β coefficients and 95% CIs were estimated using linear regression analysis. AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; CI, confidence interval; FIB-4, fibrosis-4.
^aAdjusted for sex, body mass index, smoking, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension. Chronological age was excluded to avoid mathematical overlap with the FIB-4 equation. ^bModel 2 additionally included AST, ALT, and platelet count as an exploratory component-related model. Given the mathematical relationship between these variables and FIB-4, this model should not be interpreted as an ordinary confounder-adjusted model.

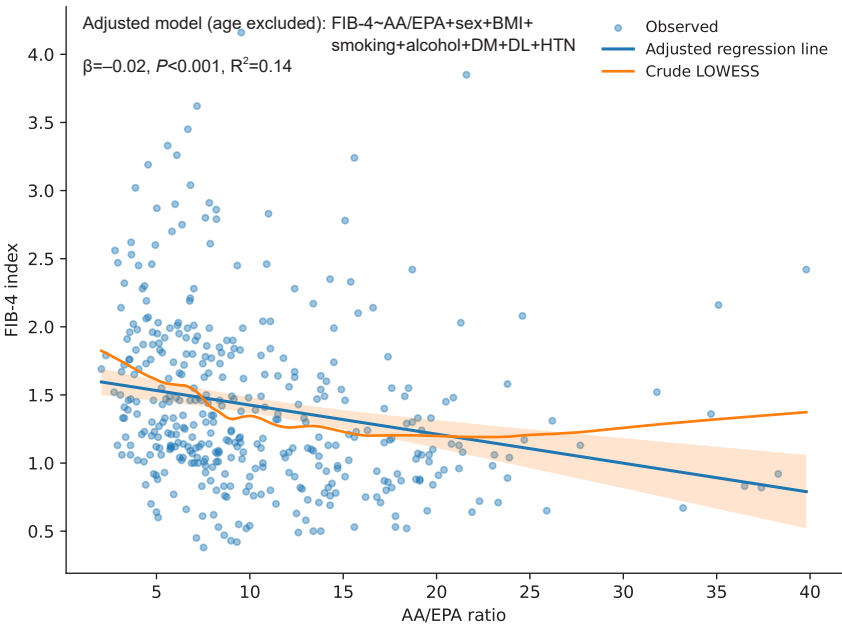


Fig. 2. Adjusted association between AA/EPA and FIB-4. The scatter plot shows the association between the AA/EPA ratio and the FIB-4 index. The blue line represents the adjusted linear regression fit, and the shaded area indicates the 95% confidence interval. The model was adjusted for sex, BMI, smoking, alcohol intake, DM, DL, and HTN; age was excluded to avoid mathematical overlap with the FIB-4 equation. The orange line shows a crude LOWESS curve for visualization. AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; BMI, body mass index; DL, dyslipidemia; DM, diabetes mellitus; FIB-4, fibrosis-4; HTN, hypertension.

tion, body mass index, smoking status, alcohol intake, diabetes mellitus, and hypertension. These factors are closely related to MASLD and may also be associated with fatty acid profiles. Therefore, adjusted analysis was used to evaluate whether AA/EPA had an independent association with MASLD after accounting for major cardiometabolic covariates. The persistence of the null association after adjustment strengthens, rather than weakens, the interpretation that AA/EPA is unlikely to be a useful standalone screening marker for MASLD in this cohort.

These findings should be interpreted in the context of the het-

erogeneity of MASLD. MASLD includes individuals with diverse metabolic profiles and prognostic trajectories, and the presence of steatosis alone does not fully capture disease severity [5,6]. Previous studies have shown that fibrosis, rather than steatosis itself, is more strongly associated with liver-related and overall mortality in fatty liver disease [7,8]. Therefore, the absence of an association between AA/EPA and MASLD status suggests that AA/EPA is unlikely to serve as a simple screening marker for MASLD in health check-up settings.

The inverse association between AA/EPA and FIB-4 should be

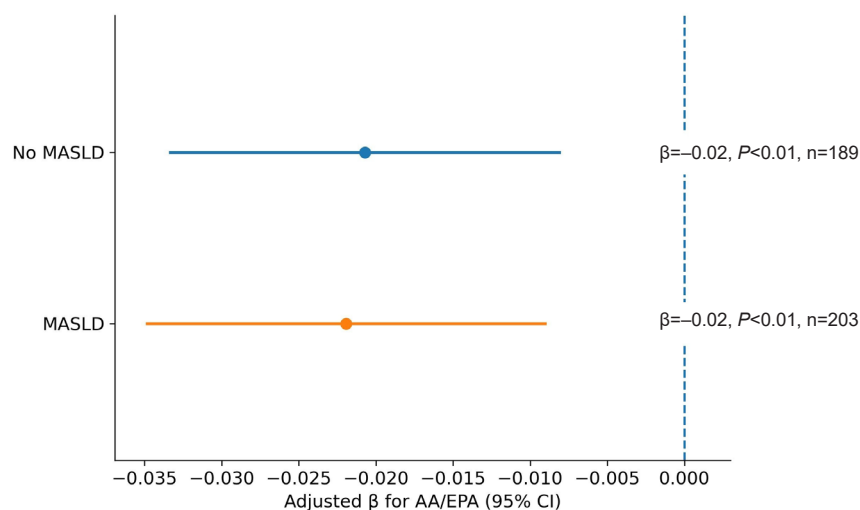


Fig. 3. MASLD-stratified association between AA/EPA and FIB-4. Adjusted β coefficients and 95% CIs are shown separately for participants without MASLD and with MASLD. Estimates were obtained from linear regression models adjusted for sex, body mass index, smoking, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension. Age was excluded to avoid mathematical overlap with the FIB-4 equation. The vertical dashed line indicates $\beta=0$.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; CI, confidence interval; FIB-4, fibrosis-4; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table 4. MASLD-stratified association between AA/EPA and FIB-4 index

Group	Participant (n)	β (95% CI)	P-value	R ²
No MASLD	189	-0.02 (-0.03 to -0.01)	<0.01	0.14
MASLD	203	-0.02 (-0.04 to -0.01)	<0.01	0.14

Adjusted β coefficients and 95% CIs are shown separately for participants without MASLD and with MASLD. Estimates were obtained from linear regression models adjusted for sex, body mass index, smoking, alcohol intake, diabetes mellitus, dyslipidemia, and hypertension. Chronological age was excluded to avoid mathematical overlap with the FIB-4 equation.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; CI, confidence interval; FIB-4, fibrosis-4; MASLD, metabolic dysfunction-associated steatotic liver disease.

Table 5. Correlations of AA/EPA with individual components of the FIB-4 index

Variable	Participant (n)	Pearson r	95% CI	P-value
AST	392	0.02	-0.08 to 0.12	0.72
ALT	392	0.06	-0.04 to 0.15	0.28
Platelet count	392	0.18	0.08 to 0.27	<0.001

Values are presented as Pearson correlation coefficients with 95% CIs. P-values were calculated using Pearson correlation analysis.

AA/EPA, arachidonic acid-to-eicosapentaenoic acid ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; CI, confidence interval; FIB-4, fibrosis-4 index.

interpreted in the context of how FIB-4 is constructed. FIB-4 is a noninvasive index based on age, AST, ALT, and platelet count, rather than a direct measure of liver fibrosis [9,10]. Nevertheless, because FIB-4 is widely used as a first-line tool for fibrosis risk stratification in MASLD care pathways, this association may still be clinically relevant [10-12].

The category-based analysis provided a clinically interpretable description of the continuous FIB-4 finding. AA/EPA was lower in participants with FIB-4 ≥ 1.3 than in those with FIB-4 < 1.3 , and an inverse trend was observed across ordered FIB-4 risk categories. However, the high-risk group with FIB-4 ≥ 2.67 included only 20 participants, and AA/EPA did not differ significantly be-

tween the intermediate- and high-risk groups. Therefore, these findings support the direction of the inverse association between AA/EPA and FIB-4, although they do not establish a clear step-wise relationship across the full spectrum of FIB-4 risk.

Previous studies have suggested that EPA/AA or AA/EPA may be related to cardiovascular, inflammatory, and metabolic risk [13-16]. A possible link between EPA/AA and fatty liver disease has also been reported, although prior studies were often conducted in selected patient populations or focused on broader fatty acid profiles rather than direct comparison between individuals with and without MASLD [16-18]. In this context, the present study adds evidence from a health check-up cohort in which MASLD and non-MASLD participants could be directly compared.

The type of blood sample used for fatty acid testing should also be considered. Previous studies have used serum, plasma, whole blood, or red blood cell membrane fractions, and these measures are not directly interchangeable [13,19-23]. In the present study, AA/EPA was derived from red blood cell membrane fatty acid composition. Therefore, direct comparison of absolute values or cutoff levels with studies using serum or plasma-based measurements is limited [19,21-23].

The biological meaning of the observed inverse association requires careful interpretation. AA/EPA was not significantly correlated with AST or ALT, whereas it was positively correlated with platelet count. Because platelet count is located in the denominator of the FIB-4 formula, the inverse association between AA/EPA and FIB-4 may partly reflect platelet-related variation rather than a liver enzyme-driven fibrosis signal [9,10]. This finding highlights an important interpretive issue when fatty acid ratios are analyzed in relation to formula-based fibrosis indices: an observed association with FIB-4 may arise from specific components of the formula rather than from fibrosis-specific hepatic biology.

At the same time, the platelet-related pattern observed in this study may represent more than a formula-driven finding. AA and EPA are involved in lipid mediator pathways related to inflammation, thrombosis, and platelet activity [14,15,17,18,24]. Experimental data have suggested that the EPA/AA balance may influence platelet aggregation and platelet mediator release [25]. However, platelet function and platelet count are not interchangeable, and recent clinical evidence does not support a major increase in bleeding risk with omega-3 PUFA use overall, except for a modest signal in some high-dose purified EPA trials [26]. Accordingly, the AA/EPA-platelet count association observed in

this study can be regarded as a hypothesis-generating finding that may link fatty acid composition with platelet-related inflammatory or thrombotic biology and warrants further investigation.

The post-hoc detectable effect size analysis suggested that the overall sample size was sufficient to detect small-to-moderate associations. However, the study may have been underpowered to detect very small between-group differences in AA/EPA according to MASLD status or subtle associations within subgroups. Therefore, the null association between AA/EPA and MASLD should be interpreted as evidence against a clinically meaningful association in this cohort, rather than as proof of no association under all conditions.

This study has several limitations. First, its cross-sectional design precludes any inference regarding causality or temporal sequence. Second, this study was conducted among health check-up examinees at a single hospital, and participants who underwent AA/EPA testing may differ from the general population in socioeconomic status, health awareness, comorbidities, and willingness to undergo optional testing. Therefore, selection bias is possible and the generalizability of the findings may be limited. Third, dietary intake, medication exposure, and supplement use may not have been fully captured, leaving the possibility of residual confounding [14,17,18]. Fourth, the marked male predominance in the MASLD group may have influenced the observed associations [5,6]. Fifth, liver fibrosis was not directly assessed by liver biopsy or elastography; fibrosis-related risk was evaluated using FIB-4, a noninvasive surrogate index [9,10,27,28].

In conclusion, AA/EPA was not associated with MASLD status, whereas it was inversely associated with FIB-4 in this Korean adult health check-up cohort. Category-based analyses supported the direction of this association, whereas component analyses suggested that platelet-related variation, rather than AST or ALT, may partly contribute to the FIB-4 finding. These findings do not support AA/EPA as a simple screening marker for MASLD. Further studies incorporating direct fibrosis assessment, platelet-related parameters, and detailed dietary or supplement information are needed to clarify the biological and clinical significance of the AA/EPA-FIB-4 association.

SUPPLEMENTARY MATERIAL

Supplementary Table 1. AA/EPA according to FIB-4 risk categories

Supplementary Table 2. Age-stratified association between AA/EPA and FIB-4

ORCID

Sung-Jae JANG, <https://orcid.org/0000-0001-7654-7326>

Bo-Kyung SHINE, <https://orcid.org/0000-0002-9160-2781>

AUTHOR CONTRIBUTIONS

Dr. Bo-Kyung SHINE had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: all authors. Data curation: SJJ. Formal analysis: SJJ. Investigation: SJJ. Methodology: all authors. Supervision: BKS. Writing—original draft: SJJ. Writing—review & editing: all authors.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

FUNDING

None.

DATA AVAILABILITY

The data presented in this study are available upon reasonable request from the corresponding author.

REFERENCES

1. Rinella ME, Lazarus JV, Ratziu V, Francque SM, Sanyal AJ, Kanwal F, et al. A multisociety Delphi consensus statement on new fatty liver disease nomenclature. *Hepatology* 2023;78(6):1966-86.
2. Younossi ZM, Golabi P, Paik JM, Henry A, Van Dongen C, Henry L. The global epidemiology of nonalcoholic fatty liver disease (NAFLD) and nonalcoholic steatohepatitis (NASH): a systematic review. *Hepatology* 2023;77(4):1335-47.
3. Teng ML, Ng CH, Huang DQ, Chan KE, Tan DJ, Lim WH, et al. Global incidence and prevalence of nonalcoholic fatty liver disease. *Clin Mol Hepatol* 2023;29(Suppl):S32-42.
4. Ahmed MH, Barakat S, Almobarak AO. Nonalcoholic fatty liver disease and cardiovascular disease: has the time come for cardiologists to be hepatologists? *J Obes* 2012;2012:483135.
5. Chan WK, Chuah KH, Rajaram RB, Lim LL, Ratnasingam J, Vethakkan SR. Metabolic dysfunction-associated steatotic liver disease (MASLD): a state-of-the-art review. *J Obes Metab Syndr* 2023;32(3):197-213.
6. Stefan N, Yki-Järvinen H, Neuschwander-Tetri BA. Metabolic dysfunction-associated steatotic liver disease: heterogeneous pathomechanisms and effectiveness of metabolism-based treatment. *Lancet Diabetes Endocrinol* 2025;13(2):134-48.
7. Ekstedt M, Hagström H, Nasr P, Fredrikson M, Stål P, Kechagias S, et al. Fibrosis stage is the strongest predictor for disease-specific mortality in NAFLD after up to 33 years of follow-up. *Hepatology* 2015;61(5):1547-54.
8. Dulai PS, Singh S, Patel J, Soni M, Prokop LJ, Younossi Z, et al. Increased risk of mortality by fibrosis stage in nonalcoholic fatty liver disease: systematic review and meta-analysis. *Hepatology* 2017;65(5):1557-65.
9. Sterling RK, Lissen E, Clumeck N, Sola R, Correa MC, Montaner J, et al. Development of a simple noninvasive index to predict significant fibrosis in patients with HIV/HCV coinfection. *Hepatology* 2006;43(6):1317-25.
10. European Association for the Study of the Liver (EASL), European Association for the Study of Diabetes (EASD), European Association for the Study of Obesity (EASO). EASL-EASD-EASO Clinical Practice Guidelines on the management of metabolic dysfunction-associated steatotic liver disease (MASLD). *J Hepatol* 2024;81(3):492-542.
11. Ishiba H, Sumida Y, Tanaka S, Yoneda M, Hyogo H, Ono M, et al. The novel cutoff points for the FIB4 index categorized by age increase the diagnostic accuracy in NAFLD: a multi-center study. *J Gastroenterol* 2018;53(11):1216-24.
12. Sung S, Al-Karaghoul M, Tam M, Wong YJ, Jayakumar S, Davyduke T, et al. Age-dependent differences in FIB-4 predictions of fibrosis in patients with MASLD referred from primary care. *Hepatol Commun* 2024;9(1):e0609.
13. Rizzo AM, Montorfano G, Negroni M, Adorni L, Berselli P, Corsetto P, et al. A rapid method for determining arachidonic:eicosapentaenoic acid ratios in whole blood lipids: correlation with erythrocyte membrane ratios and validation in a large Italian population of various ages and pathologies. *Lipids Health Dis* 2010;9:7.
14. Nelson JR, Raskin S. The eicosapentaenoic acid:arachidonic acid ratio and its clinical utility in cardiovascular disease. *Postgrad Med* 2019;131(4):268-77.
15. Calder PC. n-3 polyunsaturated fatty acids, inflammation,

- and inflammatory diseases. *Am J Clin Nutr* 2006;83(6 Suppl):1505S-19S.
16. Ishitobi T, Hyogo H, Kan H, Hiramatsu A, Arihiro K, Aikata H, et al. Eicosapentaenoic acid/arachidonic acid ratio as a possible link between non-alcoholic fatty liver disease and cardiovascular disease. *Hepatol Res* 2015;45(5):533-9.
 17. Notarnicola M, Osella AR, Caruso MG, Pesole PL, Lippolis A, Tutino V, et al. Nonalcoholic fatty liver disease: focus on new biomarkers and lifestyle interventions. *Int J Mol Sci* 2021;22(8):3899.
 18. Hliwa A, Ramos-Molina B, Laski D, Mika A, Sledzinski T. The role of fatty acids in non-alcoholic fatty liver disease progression: an update. *Int J Mol Sci* 2021;22(13):6900.
 19. Harris WS, Von Schacky C. The Omega-3 Index: a new risk factor for death from coronary heart disease? *Prev Med* 2004;39(1):212-20.
 20. Schins A, Crijns HJ, Brummer RJ, Wichers M, Lousberg R, Celis S, et al. Altered omega-3 polyunsaturated fatty acid status in depressed post-myocardial infarction patients. *Acta Psychiatr Scand* 2007;115(1):35-40.
 21. Harris WS, Thomas RM. Biological variability of blood omega-3 biomarkers. *Clin Biochem* 2010;43(3):338-40.
 22. Katan MB, Deslypere JP, van Birgelen AP, Penders M, Zegwaard M. Kinetics of the incorporation of dietary fatty acids into serum cholesteryl esters, erythrocyte membranes, and adipose tissue: an 18-month controlled study. *J Lipid Res* 1997;38(10):2012-22.
 23. Harris WS, Pottala JV, Sands SA, Jones PG. Comparison of the effects of fish and fish-oil capsules on the n 3 fatty acid content of blood cells and plasma phospholipids. *Am J Clin Nutr* 2007;86(6):1621-5.
 24. Yanagisawa N, Shimada K, Miyazaki T, Kume A, Kitamura Y, Ichikawa R, et al. Polyunsaturated fatty acid levels of serum and red blood cells in apparently healthy Japanese subjects living in an urban area. *J Atheroscler Thromb* 2010;17(3):285-94.
 25. Hashimoto Y, Naito C, Kawamura M, Oka H. Effects of the ratio of exogenous eicosapentaenoic acid to arachidonic acid on platelet aggregation and serotonin release. *Thromb Res* 1984;34(5):439-46.
 26. Javaid M, Kadhim K, Bawamia B, Cartledge T, Farag M, Alkhalil M. Bleeding risk in patients receiving omega-3 polyunsaturated fatty acids: a systematic review and meta-analysis of randomized clinical trials. *J Am Heart Assoc* 2024;13(10):e032390.
 27. Mózes FE, Lee JA, Vali Y, Alzoubi O, Stauffer K, Trauner M, et al. Performance of non-invasive tests and histology for the prediction of clinical outcomes in patients with non-alcoholic fatty liver disease: an individual participant data meta-analysis. *Lancet Gastroenterol Hepatol* 2023;8(8):704-13.
 28. Tamaki N, Imajo K, Sharpton SR, Jung J, Sutter N, Kawamura N, et al. Two-step strategy, FIB-4 followed by magnetic resonance elastography, for detecting advanced fibrosis in NAFLD. *Clin Gastroenterol Hepatol* 2023;21(2):380-7.e3.

Knowledge, Attitudes, and Practices Regarding Antenatal Care among Women in High-Risk Areas of El Salvador: A Baseline Survey for Future Program Evaluation

Yong Hyun KIM, MA¹, Elnor CRESPI, PhD², and Byung Wook YOO, MD, PhD³

¹Department of Medical Science, Graduate School, Soonchunhyang University, Asan, Korea

²ERAK Consultores, San Salvador, El Salvador

³Department of Family Medicine, Soonchunhyang University Seoul Hospital, Seoul, Korea

ABSTRACT

Background: Despite substantial improvements in maternal health indicators and near-universal institutional delivery coverage in El Salvador, limited evidence is available regarding maternal health literacy and health-seeking behaviors among women residing in socioeconomically vulnerable and geographically isolated communities. This study aimed to establish baseline evidence on knowledge, attitudes, and practices related to antenatal care and maternal health among women living in high-risk municipalities of El Salvador.

Methods: A cross-sectional baseline survey was conducted between June 2 and June 26, 2025, among 304 pregnant and postpartum women receiving care from five family community health units (UCSFs) located in high-risk municipalities of El Salvador. Data were collected using a structured 75-item questionnaire administered through KoBoToolbox. Descriptive statistics, Mann-Whitney U-tests, Pearson's chi-square tests, and Spearman correlation analyses were performed.

Results: Although antenatal care utilization was high (96.4%) and institutional delivery was nearly universal among multiparous women (97.5%), substantial gaps in technical maternal health knowledge were identified. Only 25.0% of participants demonstrated adequate knowledge regarding essential prenatal tests, and only 18.1% correctly identified the benefits of both iron and folic acid supplementation. Educational attainment was significantly associated with knowledge of prenatal tests and contraception (both $P < 0.001$), whereas age was not associated with any knowledge indicator. Significant knowledge-practice gaps were observed, particularly regarding contraception ($\chi^2 = 14.6$, $P = 0.002$) and tetanus vaccination ($P = 0.847$), suggesting the presence of structural barriers beyond individual awareness. Territorial disparities of up to 25 percentage points were observed across participating facilities.

Conclusions: High coverage of antenatal care services does not necessarily translate into adequate maternal health knowledge or optimal preventive practices. The findings identify priority areas for maternal health education and service-delivery strengthening and provide important baseline evidence for future monitoring and evaluation of maternal health interventions in vulnerable communities of El Salvador.

Keywords: Prenatal care, Health knowledge, attitudes, practice, Pregnant people, Health surveys, El Salvador

Received: June 30, 2026; **Revised:** August 10, 2026; **Accepted:** August 18, 2026

Corresponding author: Byung Wook YOO, MD, PhD

Department of Family Medicine, Soonchunhyang University Seoul Hospital, 59 Daesagwan-ro, Yongsan-gu, Seoul 04401, Korea

Tel: +82-2-709-9158 Fax: +82-2-709-9133 E-mail: dryoo@schmc.ac.kr

INTRODUCTION

Maternal mortality remains one of the most sensitive indicators of global health inequity. In 2023, more than 700 women died daily from preventable pregnancy-related causes, and although the global maternal mortality ratio (MMR) fell by nearly 40% between 2000 and 2023, more than 90% of these deaths occurred in low- and lower-middle-income countries [1]. The main direct causes—hemorrhage, hypertensive disorders, sepsis, and infection—are largely preventable through timely antenatal, intrapartum, and postpartum care [2], yet translating this knowledge into effective practice remains a challenge where geographical, socioeconomic, and cultural barriers converge.

In Latin America and the Caribbean, hypertensive disorders represent a high proportion of maternal death causes [2]. El Salvador has achieved significant reductions in its MMR, from approximately 170 per 100,000 live births in 2000 to 42.8 in 2020, attributed in part to Maternity Waiting Homes and institutionalization of childbirth. However, challenges persist: 99.8% of deliveries are attended by skilled personnel, but coverage of four or more antenatal care visits only reached 82% in 2018, with significant territorial gaps between urban and rural areas.

The knowledge, attitudes, and practices (KAP) framework has proven to be a valuable methodological tool for diagnosing the cognitive, attitudinal, and behavioral dimensions that mediate between service availability and effective utilization [3,4]. KAP studies in low- and middle-income countries have consistently documented the knowledge-practice gap: in India, Bashir et al. [3] found that 96% of women had adequate knowledge but only 58.5% had adequate practices; in Rwanda, only 23.1% exhibited good practices despite 61.2% having adequate knowledge; in Somalia, 86.5% knew about antenatal care services but only 17% complied with the recommended frequency of visits [5]. Associated factors include educational level, age, parity, family structure, and health system barriers [3-6].

Despite advances in maternal health indicators in El Salvador, empirical evidence on KAP in antenatal care remains limited in rural and peri-urban communities. The five selected family community health units (UCSFs) are in municipalities with high obstetric risk, geographical isolation, and unfavorable socioeconomic determinants. Key aspects such as knowledge about prenatal tests, adherence to iron and folic acid, tetanus vaccination, and contraception have received insufficient attention [7]. In particular, the gaps between what women know and what they actually practice have not been documented.

The present study is part of the Korea International Cooperation Agency (KOICA)-supported project entitled “Strengthening the Maternal-Neonatal Emergency Transport System in Remote High-Risk Areas of El Salvador,” implemented by Soonchunhyang University Hospital and local partners.

Accordingly, the findings presented here should be interpreted as baseline evidence reflecting the pre-intervention situation of women residing in high-risk communities. The results are intended to inform program planning, identify priority areas for intervention, and provide a reference point for future endline assessments and impact evaluations.

Despite these advances, empirical evidence on KAP related to antenatal care in El Salvador remains scarce and limited in scope. A 2018 cross-sectional survey of 207 pregnant and postpartum women attending three intermediate UCSFs reported that only about one quarter reached an acceptable level of knowledge of puerperal danger signs [8], and a national review found that women held general reproductive health knowledge while lacking specific risk-recognition skills [9]. To our knowledge, no previous study in the country has combined simultaneous measurement of the three KAP dimensions, systematic disaggregation across multiple primary care facilities, statistical quantification of knowledge-practice gaps in defined clinical domains, and a baseline design with a pre-planned second measurement round. Knowledge of prenatal tests, adherence to iron and folic acid supplementation, tetanus vaccination, and contraception have received particularly limited attention in these settings.

The specific objectives were therefore: (1) to assess baseline levels of KAP on antenatal care and maternal health; (2) to identify sociodemographic determinants of knowledge; (3) to quantify knowledge-practice gaps and territorial disparities; and (4) to establish a benchmark for future evaluation of maternal health programs in vulnerable populations.

METHODS

Study design

A descriptive cross-sectional baseline study with a KAP approach to antenatal care and maternal health was conducted. Data collection took place between June 2 and 26, 2025. This design was intended to establish baseline levels before subsequent program implementation; therefore, it does not directly estimate improvement or intervention effectiveness.

Context and study sites

The study was conducted in five UCSFs located in municipalities prioritized for high obstetric risk and socioeconomic vulnerability: Guaymango (Ahuachapán), Perquín (Morazán), Panchimalco (San Salvador), Puerto de La Libertad (La Libertad), and San Juan Nonualco (La Paz). Selection considered: (a) high rates of maternal and neonatal mortality, (b) geographical-ly remote location, and (c) significant population of women of childbearing age.

Participants and eligibility criteria

Women aged ≥ 19 years, pregnant or with delivery in the last 12 months, active users of participating UCSFs, who provided informed consent were included. Women under 19 years and those who did not consent were excluded.

The target population of this study was therefore women who are in active contact with the participating UCSFs, rather than all women of reproductive age residing in the five municipalities. Women living in these territories who do not attend the facilities and are not registered by community health promoters were not represented in the sampling frame and could not be reached by either recruitment modality.

Sample size and sampling

The target sample size of 300 participants per survey round was established a priori in the project's terms of reference, which specify two rounds of 300 analysis units each. Given that predetermined size, the corresponding precision was derived using the finite population formula for a proportion, $n = N \cdot Z^2 \cdot p \cdot q / [Z^2 \cdot p \cdot q + (N-1) \cdot e^2]$, with $N=71,110$ women of reproductive age served by the participating facilities, $Z=1.96$ and $P=0.50$; the resulting margin of error is 5.66% for $n=300$ and 5.61% for the 304 participants actually enrolled. A value of $P=0.50$ was adopted because no local prevalence estimates were available for the outcomes of interest and because the six knowledge indices span proportions from 4.3% to 99.3%, so that no single expected prevalence would have been appropriate; $P=0.50$ maximizes the required sample size and is therefore the conservative choice. The finite population correction is negligible at this order of magnitude: assuming population values between 35,000 and 1,000,000 alters the required sample size by fewer than three participants.

The five UCSFs constituted the sampling strata, with equal allocation of 60 questionnaires per facility. Equal rather than proportional allocation was chosen deliberately to preserve statistical power for between-facility comparisons, which were a

primary objective of the study. No design effect was applied, as participants were selected directly within each stratum without intermediate clustering stages. One consequence of equal allocation should be noted: because the populations served by the five facilities differ substantially in size, the pooled percentages reported throughout the Results are unweighted summaries across sites and estimate the average across facilities rather than a population-weighted parameter for the combined territory. The final sample comprised 304 women (101% of target): Guaymango ($n=60$), Perquín ($n=60$), Panchimalco ($n=60$), Puerto de La Libertad ($n=63$), and San Juan Nonualco ($n=61$).

Data collection instrument

A structured 75-item KAP questionnaire was used, organised in five modules: (I) sociodemographic data, (II) obstetric history, (III) knowledge, (IV) attitudes, and (V) practices. Item content was based on World Health Organization (WHO) conceptual frameworks for antenatal care [10] and on the national Born with Care Law [11]. The questionnaire was developed directly in Spanish, the language of the study population, and administered in Spanish; it is not an adaptation of an instrument validated in another language, and no translation or back-translation procedure was therefore involved. Item wording reproduced in the [Supplementary Material 1](#) is a translation prepared for reporting purposes only. Data were captured digitally using KoBoToolbox.

Content validity was assessed through qualitative review by 2 maternal health specialists of the Ministry of Health of El Salvador; a quantitative content validity index was not computed. The instrument was subsequently pilot tested with 7 women at a UCSF not included in the study sample; the Pilot Test was carried out on Wednesday, March 12, 2025, in coordination with the Ministry of Health, at the Nejapa Health Unit, Nejapa district, San Salvador department; pilot participants were not included in the final sample of 304. Following the pilot study, the attitudes response scale was revised by removing the neutral midpoint to reduce central-tendency responses and improve response discrimination in a population with predominantly basic educational attainment. The codes of the remaining categories were retained, which is why the response codes are non-consecutive.

Attitudes were assessed with 12 items on a four-point Likert scale (1=strongly agree, 2=agree, 4=disagree, 5=strongly disagree; no neutral category), organized into five thematic blocks: value of antenatal care (C28, C29, C31), clinical procedures and screening (C32, C33, C34), nutrition and supplementation

(C35, C36), risk behaviours during pregnancy (C39, C40), and safe delivery and reproductive health (C38, C42). Item C38 is negatively worded and was reverse-coded prior to analysis. Cronbach's alpha was 0.922 for the full 12-item scale and 0.917, 0.926, 0.822 and 0.969 for the first four blocks respectively; the fifth block comprises two items addressing independent domains that do not form a unidimensional scale ($r=0.080$), and these are reported individually. The blocks represent a thematic organization of the questionnaire rather than psychometrically distinct dimensions: principal components analysis indicated an essentially unidimensional structure, with the first component accounting for 62.3% of the variance.

Data collection

Fieldwork between June 2 and 26, 2025, with two modalities: (a) administration at UCSFs during antenatal consultations, and (b) home visits with community health promoters. The questionnaire was administered face-to-face by trained interviewers, with digital capture via KoboToolbox and field supervision.

Variables and measurements

Knowledge was assessed through six categorical indices. Three indices derived from multiple-response items (reasons for antenatal care, essential prenatal tests, and contraceptive methods) were categorized into four levels: no knowledge, low, partial and high. The numerical thresholds defining each level differ across these indices because their score ranges are not equivalent (0 to 4 for the first two and 0 to 7 for contraception); the specific rules are given in [Supplementary Material 1](#). The iron and folic acid index was categorized into three levels (no knowledge, partial and high), since the underlying item admits only two correct reasons and a fourth level is not constructible. Two indices (early initiation and safe place of delivery) are binary by construction and were classified as adequate or inadequate. Where results are aggregated, "partial or high knowledge" denotes a score of 2 or above on the four-level indices. The prenatal tests index measures recognition of four pre-specified tests rather than knowledge of antenatal testing as a whole; responses recorded under the item's open-ended option were not incorporated into the score. Full item wording, scoring rules and categorization thresholds are provided in [Supplementary Material 1](#).

Two of the six indices (early initiation and safe place of delivery) are based on items phrased as normative endorsement rather than as factual recall, and overlap conceptually with two items in the attitudes block (C31 and C38 respectively). They

are reported as knowledge indices for consistency with the questionnaire structure, but are distinguished throughout from the four indices assessing technical content, with which they show no consistent association.

The knowledge-practice gap analysis was restricted to selected domains according to three criteria: the knowledge index had to assess technical content rather than normative endorsement, so that the notion of a gap between knowledge and practice is conceptually applicable; a directly corresponding practice variable had to be available; and the resulting contingency table had to satisfy the minimum expected frequency assumptions of the test applied. On this basis, the early initiation and safe place of delivery indices were excluded as measures of normative endorsement, and the antenatal care reasons index was excluded because the corresponding practice variable (regular attendance, 96.4%) is so heavily skewed that three of the eight cells would have expected frequencies below five. These criteria were applied during analysis and were not pre-specified.

Knowledge of tetanus vaccination was assessed with two items. Item C14 asks why the vaccine is given during pregnancy (options: to protect the baby, to protect the mother, to protect both, do not know) and was dichotomized into women identifying any protective purpose and women reporting not knowing. Item C15 asks how many doses a pregnant woman should receive (one, two, three or more, do not know). Both are reported. Further knowledge items in the module, including recognition of obstetric danger signs, were not incorporated into the indices; three of them (effects of tobacco, alcohol and infection) showed unanimous or near-unanimous responses. Full descriptive results for the complete instrument are reported in the project's baseline report.

Statistical analysis

Data were analyzed using SPSS version 28.0 (IBM Corp.). Normality was verified using the Shapiro-Wilk test, confirming non-normal distributions for all indices, justifying non-parametric tests. Sociodemographic-knowledge associations: Mann-Whitney U-test. Categorical associations: Pearson's chi-square test. Correlations: Spearman correlation analysis between the six indices. Knowledge-practice gaps: cross-tabulations with chi-square. Territorial disaggregation by UCSF for all indicators. Significance level $\alpha=0.05$. Because multiple statistical tests were performed, additional sensitivity analyses using appropriate corrections for multiple comparisons were conducted to assess the robustness of statistically significant findings.

A sensitivity analysis was performed comparing currently pregnant and postpartum women to assess whether pooling both groups influenced the study findings.

Ethical considerations

Protocol approved by the National Committee on Health Research Ethics of El Salvador (CNEIS) (May 5, 2025) and the Bioethics Committee of Soonchunhyang University. Informed consent from all participants. Confidentiality, anonymity, and right of withdrawal guaranteed. In accordance with the Declaration of Helsinki and national regulations.

RESULTS

Sociodemographic and obstetric profile

The sample of 304 participants (Table 1, Supplementary Table 1) was predominantly young (mean±standard deviation, 27.5±6.0 years), with 54.9% having maximum education of ninth grade

and only 5.3% with higher education. 90.4% were in a conjugal union and 78.6% were homemakers. 60.9% were pregnant at the time of the survey, 79.9% were multiparous, and 97.5% of those with previous births had them in hospital. Among women in union, 14.2% reported entering a union before 18 years of age.

Knowledge levels

Table 1 presents the six constructed knowledge indices. A dichotomous pattern was identified. Endorsement of the norms of early antenatal care initiation (99.3%) and of institutional delivery (98.7%) was near-universal, whereas knowledge of specific technical content was markedly deficient: only 25.0% reached partial or high knowledge of essential prenatal tests, with blood pressure monitoring identified by only 4.6%, and only 18.1% recognized both benefits of iron and folic acid supplementation. In contraception, although 96.1% had some level of knowledge, 63.5% remained at partial level.

Sensitivity analyses showed no significant differences between

Table 1. Knowledge about maternal and reproductive health according to constructed indices (n=304)

Variable	Category	Participant (n)	Percentage
1. Antenatal care			
Knowledge level	No knowledge	9	3.0
	Low (1 correct answer)	120	39.5
	Partial (2–3 correct)	162	53.3
	High (4 correct)	13	4.3
2. Early Antenatal care initiation			
Importance of attending	Yes (adequate knowledge)	302	99.3
Antenatal care in 1st trimester	No/Don't know	2	0.7
3. Prenatal tests			
Knowledge level	No knowledge (0 tests)	42	13.8
	Low (1 test identified)	186	61.2
	Partial (2–3 tests)	74	24.3
	High (4 correct tests)	2	0.7
Tests identified (multiple response)	Blood sugar	168	55.3
	Blood for infections	160	52.6
	Blood pressure	14	4.6
	Blood type	6	2.0
4. Iron and folic acid			
Knowledge level	No knowledge	4	1.3
	Partial (1 correct reason)	245	80.6
	High (both reasons)	55	18.1
5. Safe place for delivery			
Knowledge	Hospital or clinic (adequate)	300	98.7
	Home/Don't know	4	1.3
6. Contraception			
Knowledge level	No knowledge	12	3.9
	Partial knowledge	193	63.5
	Adequate knowledge	94	30.9
	High knowledge	5	1.6

Indices constructed according to WHO/Ministry of Health of El Salvador (MINSAL) criteria. Multiple response items do not sum to 100%. See Supplementary Material 1 for complete methodology.

currently pregnant and postpartum women for any knowledge index (all $P \geq 0.137$).

Sociodemographic determinants of knowledge

Educational level was significantly associated with knowledge about prenatal tests ($U=13,798.5$, $P<0.001$) and contraception ($U=14,619.5$, $P<0.001$). Women with high school or higher education obtained significantly higher scores on both indices (Table 2, Supplementary Table 2). In contrast, age group (19–35 years vs. >35 years) was not associated with any knowledge indicator (all $P>0.19$).

Attitudes toward antenatal care

Attitudes were overwhelmingly favorable: 100% recognized the importance of antenatal care, 100% agreed with the need for regular medical visits and blood pressure monitoring, and 95.7% rejected home delivery. However, 5.3% did not consider contraception important, concentrated among women >35 years (11.4%) and Guaymango (11.7%). 63.8% reported attend-

ing the health center by their own decision ($C30=1$), a slightly higher proportion among household heads (68.5%) than non-heads (62.8%), although the difference was not statistically significant ($\chi^2=0.406$, $P=0.524$) (Supplementary Table 3).

Agreement was near-universal across all attitude items, and the variance observed corresponded to the intensity of agreement rather than to its direction: 78.3% of participants selected the same response category across the eight core items. Internal consistency was accordingly high (Cronbach's alpha 0.922 for the 12-item scale), but this reflects homogeneity of response style as much as coherence of the underlying construct, and indicates that the scale does not discriminate within this population.

Maternal health practices

Antenatal care attendance was high (96.4%) and 97.5% of multiparous women had their last delivery in hospital. However, iron and folic acid supplementation showed inconsistent adherence: although 77.3% reported current consumption, 36.5%

Table 2. Analysis of knowledge-practice gaps in maternal health (n=304)

Panel A: Contraception vs. previous use					
Knowledge level	Positive practice	No practice	Total	% No practice	Test
No knowledge	2	10	12	83.3%	$\chi^2=14.6$; $P=0.002^a$
Low	134	59	193	30.6%	
Partial	60	34	94	36.2%	
High	4	1	5	20.0%	
Total	200	104	304	34.2	
Panel B: Iron/Folic acid—Knowledge vs. adherence					
Knowledge level	Never forgets	Forgets/No intake	Total	% Adherent	
No knowledge	1	3	4	25.0%	$\chi^2=2.594$; $P=0.273^a$
Partial knowledge	157	88	245	64.1%	
High knowledge	35	20	55	63.6%	
Total	193	111	304	63.5	
Panel C: Tetanus—Knowledge vs. vaccination ≥ 2 doses					
Tetanus knowledge	≥ 2 doses	<2 doses	Total	% Adequate	
Knows purpose	69	137	206	33.5%	$\chi^2=0.037$; $P=0.847^b$
Doesn't know/Don't know	31	67	98	31.6%	
Total	100	204	304	32.9	
Panel D: Tetanus—knowledge of the recommended number of doses vs. vaccination with ≥ 2 doses					
Doses believed necessary	≥ 2 doses	<2 doses	Total	% ≥ 2 doses	Test
One	18	90	108	16.7	-
Two	38	32	70	54.3	-
Three or more	23	14	37	62.2	-
Does not know	21	68	89	23.6	$\chi^2=45.24$; $P<0.001^a$
Total	100	204	304	32.9	

Panel A, contraception knowledge vs. previous use. Panel B, iron and folic acid knowledge vs. adherence. Panel C, knowledge of the purpose of tetanus vaccination vs. receipt of two or more doses. Panel D, knowledge of the recommended number of doses vs. receipt of two or more doses.

^aPearson's chi-square test. ^bchi-square with continuity correction (Pearson's $\chi^2=0.104$, $P=0.747$; Fisher's exact $P=0.795$). In Panels A and B, three of eight and two of six expected cell frequencies were below 5 respectively, and the corresponding results should be interpreted with caution; all expected frequencies were 5 or above in Panels C and D. In Panel D, the test for linear trend across the three categories in which a number was stated was significant ($\chi^2=34.21$, degree of freedom=1, $P<0.001$). Knowledge levels are defined in Supplementary Material 1; items C14 and C15 are documented in the Methods.

did not take it daily. Tetanus vaccination coverage was notably low, with only 8.2% having three or more doses. Previous use of contraceptives was reported by 65.8%, leaving 34.2% who never used any method. Consumption of harmful substances was minimal: no participant reported tobacco use (C53), one reported alcohol consumption (0.3%), and seven reported self-medication (2.3%) ([Supplementary Table 3](#)).

Knowledge-practice gaps

[Table 2](#) presents the knowledge-practice gaps examined in four domains. For contraception (Panel A), 34.2% of participants had never used any method despite 96.1% reporting some level of knowledge. The association between knowledge level and prior use was significant ($\chi^2=14.6$, degree of freedom [df]=3, $P=0.002$), although three of the eight expected cell frequencies were below 5. Decomposition indicates that this does not reflect a gradient across knowledge levels: among women with at least some knowledge, prior use did not differ between those with low or partial and those with high knowledge (Fisher's exact $P=0.797$). The difference is confined to the 12 women reporting no knowledge at all, of whom 83.3% had never used contraception, compared with 32.2% of the remainder (Fisher's exact $P=0.0005$). Even among women with partial knowledge, 36.2% had never used contraception.

For iron and folic acid (Panel B), adherence did not differ between women with partial and high knowledge (64.1% and 63.6% respectively; difference +0.4 percentage points, 95% confidence interval [CI] -13.6 to +14.5; Fisher's exact $P>0.99$). Four women reported no knowledge, of whom one was adherent; this subgroup is too small to support inference and is reported descriptively only.

For tetanus vaccination, two knowledge items were examined. Knowledge of the purpose of the vaccine (Panel C) was not associated with receipt of two or more doses (33.5% versus 31.6%; difference +1.9 percentage points, 95% CI -9.4 to +13.1; $P=0.847$). Knowledge of the recommended number of doses (Panel D), by contrast, was strongly associated with vaccination status ($\chi^2=45.24$, df=3, $P<0.001$), with a significant linear trend among women who stated a number ($\chi^2=34.21$, df=1, $P<0.001$): 16.7% of those who believed one dose sufficient had received two or more, compared with 54.3% of those who stated two doses and 62.2% of those who stated three or more. Women who reported not knowing occupied an intermediate position (23.6%). Considered dichotomously, 57.0% of women who correctly stated that two or more doses are required had received

them, compared with 19.8% of the remainder (difference +37.2 percentage points, 95% CI +26.3 to +48.1; odds ratio 5.37, 95% CI 3.20-9.03).

Territorial disparities

[Fig. 1](#) illustrates knowledge profiles by UCSF. Territorial differences were formally evaluated using chi-square tests of homogeneity across the five participating UCSFs. Significant heterogeneity was observed for tetanus vaccination coverage ($\chi^2=16.05$, $P=0.003$), adequate knowledge of contraception ($\chi^2=14.36$, $P=0.006$), prior contraceptive use ($\chi^2=12.02$, $P=0.017$), and adherence to iron and folic acid supplementation ($\chi^2=9.68$, $P=0.046$). After controlling the false discovery rate using the Benjamini-Hochberg procedure, the first three indicators remained statistically significant, whereas the difference in adherence to iron and folic acid supplementation did not. In contrast, variation in knowledge of prenatal tests was not statistically significant ($\chi^2=5.32$, $P=0.256$). These findings indicate that territorial heterogeneity is confined to selected maternal health domains rather than representing a generalized pattern across all indicators. Disparities reached up to 25 percentage points ([Supplementary Table 3](#)).

Correlations between domains and nutritional profile

Spearman correlation analysis revealed two clusters among knowledge indices ([Supplementary Table 4](#)), suggesting that interventions in one domain may generate effects in correlated domains. The nutritional profile showed moderate dietary diversity (mean 4.96/7 groups) with low consumption of healthy fats (31.9%) and protein reduction in 24.3%. 45.4% reported disturbed sleep, with significant territorial variations ($\chi^2=13.09$, $P=0.011$) ([Supplementary Table 5](#)).

DISCUSSION

Attitudes were overwhelmingly favorable across all domains assessed. This should be read as a measurement ceiling rather than as a differentiating finding: agreement approached unanimity on every item, response style was highly homogeneous, and the scale therefore did not discriminate within this population. The substantive implication is nonetheless important. If attitudes are uniformly favorable while knowledge of technical content and several preventive practices remain deficient, the constraint on optimal maternal health outcomes in these territories lies at the structural level rather than the attitudinal one—

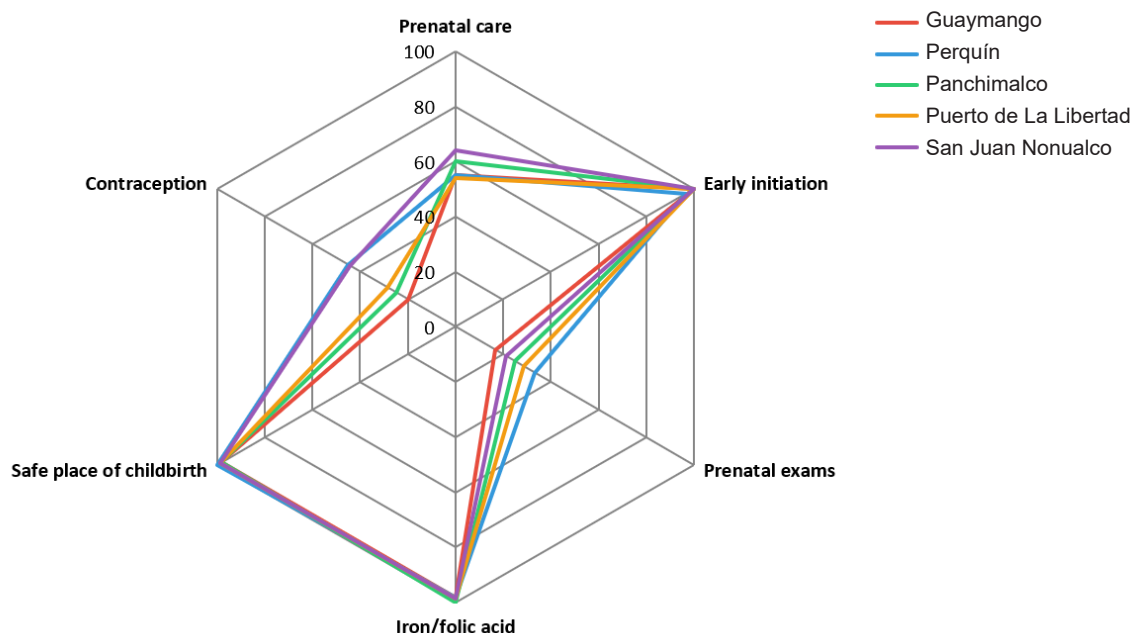


Fig. 1. Profile of adequate knowledge by family community health unit (%).

a distinction with direct consequences for programme design, since interventions aimed at persuading women of the value of antenatal care address a barrier that these data do not identify.

To our knowledge, this is the first study in El Salvador to combine simultaneous measurement of KAP regarding antenatal care with systematic territorial disaggregation across multiple primary care facilities, statistical quantification of knowledge–practice gaps, and a baseline design with a pre-planned follow-up round. Earlier work in the country has addressed isolated components of this set, in single facilities or through review of unpublished academic literature [8,9]. The findings reveal a paradoxical pattern: almost universally favorable attitudes coexist with gaps in specific knowledge and with a notable dissociation between knowledge and practice.

Endorsement of the norm of early antenatal care initiation was near-universal in our sample (99.3%). This figure is not directly comparable with the composite knowledge scores reported in other KAP studies—96% with adequate knowledge in India [3], 84.1% with good knowledge in Eritrea [12] or 86.5% aware of antenatal care services in Somalia [5]—since those indices aggregate several items of technical content whereas ours reflects agreement with a single normative statement. What the comparison does suggest is that awareness of the value of antenatal care is not the limiting factor in this population, a conclusion consistent with the pattern reported in each of those

settings, where favorable knowledge or attitudes coexisted with deficient practice.

Knowledge pattern: general strengths, specific fragilities

Knowledge about the importance of antenatal care and its early initiation was almost universal (99.3%), surpassing KAP studies in India (96%) [3], Eritrea (85.1%) [12], and Somalia (86.5%) [5]. However, only 25% had adequate knowledge about essential prenatal tests and merely 18.1% comprehensively understood the function of iron and folic acid. This pattern—where women internalize the message to “attend care” but lack technical understanding—has been described as the “coverage-knowledge gap” and documented in Mexico [13], where women received only 67.7% of necessary clinical actions despite high coverage. Correlation analysis revealed groupings among indices, supporting an integrated prenatal education approach in line with WHO recommendations.

Educational level as a structural determinant

Educational level was the only factor significantly associated with knowledge about prenatal tests ($P < 0.001$) and contraception ($P < 0.001$), consistent with international literature [3,14]. In contrast, age was not associated with any indicator (all $P > 0.19$), suggesting homogeneous knowledge distribution across age groups, possibly reflecting the effectiveness of reproductive

health campaigns. This result contrasts with studies in India [3] and Somalia [5] where age was a significant predictor.

The knowledge–practice gap

The most relevant finding is the quantification of knowledge–practice gaps. In contraception, 34.2% never used contraceptives despite 96.1% having knowledge ($\chi^2=14.6$, $P=0.002$), a phenomenon also documented in India [3].

The tetanus findings distinguish between two forms of knowledge with markedly different associations. Knowing why the vaccine is given showed no association with having received it, whereas knowing how many doses are required was strongly associated with vaccination status, following a monotonic gradient. The most instructive contrast lies at the lower end of that gradient: women who believed a single dose to be sufficient had the lowest coverage of any group in the sample (16.7%), below even those who reported not knowing (23.6%). A specific incorrect belief was thus associated with poorer practice than the absence of any belief, which is consistent with the interpretation that women who consider the schedule already complete have no reason to return.

This pattern suggests that awareness of the rationale for maternal immunisation is not by itself sufficient, and that the schedule is the more actionable target for health education in these settings. The finding should be interpreted with the caution appropriate to a cross-sectional design: women who have completed their vaccination series may also have had more opportunity to learn the schedule, and the direction of the association cannot be established from these data. Supply-side conditions, which we did not measure, may also contribute.

Favorable attitudes as a platform for action

Attitudes were overwhelmingly positive (>95%), surpassing studies in similar contexts (56%–89%) [5]. The coexistence of favorable attitudes with deficient practices suggests that barriers operate at the structural level, not attitudinal—a critical distinction for intervention design that must focus on facilitating access to services and commodities [4,15].

Territorial disparities

Territorial analyses revealed that some local differences are not evident in aggregate estimates. Although descriptive variations were observed across health facilities, statistically significant differences were identified only for selected indicators, while no significant differences were found in knowledge of prenatal tests.

These findings suggest that geographically targeted interventions should focus on indicators showing demonstrated territorial variation. Because this study provides baseline evidence, future KAP surveys using the same questionnaire and knowledge indices should assess changes following program implementation. From a public health perspective, priority actions should strengthen health education on prenatal tests, iron and folic acid supplementation, tetanus vaccination, and postpartum contraception, while simultaneously addressing service-delivery barriers through improved follow-up systems, reminder mechanisms, vaccine availability, and counseling adapted to each UCSF.

Implications for public health intervention and evaluation

The present findings have important implications for maternal health programming in vulnerable and geographically isolated communities. First, educational interventions should move beyond promoting antenatal care attendance and focus on improving women's understanding of the clinical purposes of prenatal examinations, iron and folic acid supplementation, tetanus vaccination, and postpartum family planning. Second, the substantial knowledge–practice gaps identified in this study suggest that educational efforts alone are unlikely to be sufficient. Strengthening service-delivery systems—including follow-up mechanisms, continuity of care, vaccine availability, reminder systems, and culturally appropriate counseling—may be equally important for improving maternal health behaviors. Finally, the considerable variation observed across UCSFs highlights the importance of context-specific intervention strategies rather than uniform approaches. Future maternal health programs should therefore combine educational, behavioral, and health-system interventions tailored to local needs and resource constraints.

Limitations

Limitations to consider: (1) the cross-sectional baseline design prevents causal inferences and cannot measure improvement over time without a follow-up survey; (2) self-report may be subject to social desirability bias; (3) the study population consisted of women in active contact with the participating facilities, and the sampling frame therefore excluded women residing in the same municipalities who do not use these services. This is a limitation of external validity: the findings characterize women already reached by the health system rather than the full population of women of reproductive age in high-risk areas. The likely direction of this bias can be reasoned. Nationally, approximately one in nine women with a recent live birth re-

ports no antenatal care contact, and evidence from the region indicates that women outside the system are disproportionately of lower educational attainment and greater geographical isolation. Because educational attainment was the only sociodemographic characteristic significantly associated with knowledge in our sample, the knowledge gaps reported here are likely to be conservative estimates of those present in the full population of the five municipalities; (4) the sample size per facility ($n=60$) limits power for specific subgroups; (5) non-response rate was not systematically recorded; and (6) declarative knowledge was assessed, not functional understanding. Future studies should incorporate pre-post or longitudinal designs, and may benefit from mixed-methods interviews to deepen understanding of contextual barriers.

(7) Selection within strata combined probabilistic selection from community registers with consecutive enrolment at the facilities; the design is therefore not a fully probabilistic sample of eligible women in each catchment area, and the facility component may over-represent women with greater ease of access to services. Refusals and non-contacts were not systematically recorded, so a participation rate cannot be reported.

Pooled estimates were not weighted by the population served by each facility. In addition, the home-visit modality recruited participants within rural communities, which may introduce a degree of intra-community correlation that was not quantified.

Associations between sociodemographic characteristics and knowledge were examined with unadjusted bivariate tests; the instrument did not include a direct measure of socioeconomic position, so residual confounding cannot be excluded. Where no association was detected, CIs were wide and do not exclude moderate differences; (8) This study involved multiple statistical comparisons, which may increase the probability of type I error. Therefore, additional sensitivity analyses using correction procedures for multiple comparisons were performed. Although some associations were attenuated after correction, the principal findings remained consistent, supporting the overall interpretation of the study; (9) Sensitivity analyses comparing currently pregnant and postpartum participants showed no significant differences in any of the six knowledge indices. However, receipt of two or more tetanus vaccine doses differed between the groups because vaccination schedules are necessarily incomplete for ongoing pregnancies. Consequently, this indicator should be interpreted with caution. Additionally, recruitment modality (facility versus community) could not be evaluated because this information was not recorded in the final dataset.

Conclusions

This baseline study among women attending five UCSFs in high-risk municipalities of El Salvador showed that high utilization of antenatal care services does not necessarily translate into adequate maternal health knowledge or optimal preventive practices. While awareness regarding the importance of antenatal care was nearly universal, important deficiencies remained in technical knowledge related to prenatal examinations, micronutrient supplementation, and reproductive health. Educational attainment emerged as the principal determinant of maternal health knowledge, whereas age showed no significant association.

Significant knowledge–practice gaps were identified, particularly in contraception and tetanus vaccination, suggesting that improvements in maternal health outcomes will require not only educational interventions but also the reduction of structural and service-delivery barriers. The observed territorial disparities further emphasize the need for locally tailored maternal health strategies.

Taken together, these findings provide important baseline evidence for maternal health programming in vulnerable communities of El Salvador and establish a benchmark for future monitoring and evaluation of the KOICA-supported maternal and neonatal health project. Future follow-up surveys using the same methodology will enable assessment of changes in KAP, and service utilization over time.

SUPPLEMENTARY MATERIAL

Supplementary Material 1. Methodological basis for the construction of knowledge indices. Describes construction criteria, categorization thresholds, and technical rationale (WHO/Ministry of Health of El Salvador) for the six knowledge indices used in the study.

Supplementary Table 1. Sociodemographic and obstetric characteristics of participants

Supplementary Table 2. Association between educational level and age group with knowledge and practice indicators

Supplementary Table 3. Key KAP indicators disaggregated by health facility

Supplementary Table 4. Spearman correlations between knowledge indices

Supplementary Table 5. Nutritional profile and well-being of participants

ORCID

Yong Hyun KIM, <https://orcid.org/0009-0005-9575-5258>
 Elnor CRESPI, <https://orcid.org/0009-0000-8292-1679>
 Byung Wook YOO, <https://orcid.org/0000-0002-8753-9660>

AUTHOR CONTRIBUTIONS

Dr. Byung Wook YOO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: BWY. Data curation: EC. Formal analysis: EC. Funding acquisition: BWY. Investigation: EC. Methodology: YHK. Project administration: BWY. Supervision: YHK and BWY. Writing—original draft: EC. Writing—review & editing: all authors.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

FUNDING

Funded by KOICA under the project “Strengthening the Maternal-Neonatal Emergency Transport System in Remote High-Risk Areas of El Salvador,” implemented by Soonchunhyang University Hospital and ERAK Consultores. The funder had no role in study design, data collection, analysis, or manuscript preparation.

DATA AVAILABILITY

The datasets are available from the corresponding author upon reasonable request. The instrument and methodological basis are included as supplementary files.

ACKNOWLEDGMENTS

The authors thank the participating women, staff of the five UCSFs, community health promoters, and the survey team. The support of Ministry of Health of El Salvador (MINSAL) in technical validation of the instrument is acknowledged.

REFERENCES

1. World Health Organization. Trends in maternal mortality 2000 to 2023: estimates by WHO, UNICEF, UNFPA, World Bank Group and UNDESA/Population Division. WHO; 2025.
2. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller AB, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Glob Health* 2014;2(6):e323-33.
3. Bashir S, Ansari AH, Sultana A. Knowledge, attitude, and practice on antenatal care among pregnant women and its association with sociodemographic factors: a hospital-based study. *J Patient Exp* 2023;10:23743735231183578.
4. Mohseni M, Mousavi Isfahani H, Moosavi A, Dehghanpour Mohammadian E, Mirmohammadi F, Ghazanfari F, et al. Health system-related barriers to prenatal care management in low- and middle-income countries: a systematic review of the qualitative literature. *Prim Health Care Res Dev* 2023;24:e15.
5. Elmi EOH, Shire AA, Mohamud SA, Ibrahim NA, Omar NM. Knowledge, attitude, and practice of antenatal care among pregnant women: a community-based cross-sectional study in Bosaso, Puntland, Somalia. *Int J Community Med Public Health* 2026;13(1):43-50.
6. Miiikkulainen A, Abdirahman Mohamud I, Aqazouz M, Abdullahi Suleiman B, Sheikh Mohamud O, Ahmed Mohamed A, et al. Antenatal care utilization and its associated factors in Somalia: a cross-sectional study. *BMC Pregnancy Childbirth* 2023;23(1):581.
7. Heredia-Pi I, Servan-Mori E, Darney BG, Reyes-Morales H, Lozano R. Measuring the adequacy of antenatal health care: a national cross-sectional study in Mexico. *Bull World Health Organ* 2016;94(6):452-61.
8. Melara Cerna HG, Miranda Guzmán CF, Moreno Colato SL. Knowledge of danger signs and symptoms during the puerperium among pregnant and postpartum women attending intermediate family community health units [thesis]. Universidad de El Salvador; 2018. Spanish.
9. Jandres M. Preconception care: gaps in sexual and reproductive health care in El Salvador. *Alerta* 2019;2(2):173-80. Spanish.
10. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. WHO; 2016.
11. Asamblea Legislativa de la República de El Salvador. Ley Nacer con Cariño para un Parto Respetado y un Cuidado Cariñoso y Sensible para el Recién Nacido. Decreto Legislativo n.º 123, de 17 de agosto de 2021. Diario Oficial n.º 159, Tomo 432, 23 de agosto de 2021. Spanish.

12. Gebremariam H, Tesfai B, Tewelde S, Kiflemariam Y, Kibreab E. Level of knowledge, attitude, and practice of pregnant women on antenatal care in Amater Health Center, Massawa, Eritrea: a cross-sectional study, 2019. *Infect Dis Obstet Gynecol* 2023;2023:1912187.
13. Doubova SV, Quinzaños Fresnedo C, Paredes Cruz M, Perez-Moran D, Pérez-Cuevas R, Meneses Gallardo V, et al. A comprehensive assessment of care competence and maternal experience of first antenatal care visits in Mexico: insights from the baseline survey of an observational cohort study. *PLoS Med* 2024;21(9):e1004456.
14. Adedokun ST, Yaya S. Correlates of antenatal care utilization among women of reproductive age in sub-Saharan Africa: evidence from multinomial analysis of demographic and health surveys (2010-2018) from 31 countries. *Arch Public Health* 2020;78(1):134.
15. Prata N, Weidert K, Sreenivas A. Meeting the need: youth and family planning in sub-Saharan Africa. *Contraception* 2013; 88(1):83-90.

Prediction Models for Unplanned Removal of Peripherally Inserted Central Catheters and Their Risk Factors: A Narrative Review

Seon Min LEE, MS, RN¹ and Jeong Yun PARK, PhD, RN²

¹Department of Biohealth & Medical Engineering, Gachon University, Seongnam, Korea

²Department of Clinical Nursing, University of Ulsan, Seoul, Korea

ABSTRACT

Background: While peripherally inserted central catheters (PICCs) are widely used for medium- to long-term venous therapies, complications such as infection, venous thrombosis, occlusion, and dislodgement frequently lead to unplanned removal before treatment completion. This review aimed to describe prediction models for unplanned PICC removal and its precipitating complications in adults, focusing on their methodological characteristics, retained predictors, and the extent of external validation.

Methods: This narrative review followed a structured literature search across PubMed, Scopus, and Google Scholar for articles published from database inception to August 2026, using keywords related to PICCs, unplanned removal, complications, risk factors, and prediction models in adults. Studies were categorized according to whether the predicted outcome was unplanned removal itself or a precipitating complication, and were narratively synthesized.

Results: Fourteen prediction-model studies were included; 3 predicted removal itself and 11 predicted a removal-precipitating complication, most commonly venous thrombosis. The predictors retained in the final models were distributed multidimensionally across the patient, catheter, and treatment/management domains; elevated D-dimer, a history of venous thromboembolism, and the number of catheter lumens recurred most consistently, whereas the direction of catheter material and valve type was inconsistent between models that used different outcome definitions. None of the three models targeting removal itself retained the number of lumens, all three were developed in single centers, and only one was externally validated.

Conclusions: The value of predictors and prediction models is realized through risk-based monitoring; because much of this monitoring is performed by nurses, integrating catheter placement, prediction models, and risk-factor-based patient monitoring into the nursing workflow is proposed as a direction for future research and practice. No included study evaluated the clinical effect of such integration, which therefore remains to be demonstrated.

Keywords: Peripheral catheterization, Device removal, Complications, Risk factors, Predictive learning models

Received: August 17, 2026; **Revised:** September 16, 2026; **Accepted:** September 17, 2026

Corresponding author: Jeong Yun PARK, PhD, RN

Department of Clinical Nursing, University of Ulsan, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea

Tel: +82-2-3010-5333 Fax: +82-2-3010-5332 E-mail: pjyun@ulsan.ac.kr

INTRODUCTION

A peripherally inserted central catheter (PICC) is a central venous access device that is typically inserted through the brachial or basilic vein and positioned with its tip at the cavoatrial (superior vena cava–right atrium) junction. Because it can be placed at the bedside under ultrasound guidance, carries a lower risk of insertion-related mechanical complications such as pneumothorax and hemothorax than centrally inserted central catheters (CICCs), and allows medium- to long-term maintenance including outpatient and home settings, its use has continued to expand in chemotherapy, parenteral nutrition, and long-term intravenous antibiotic therapy [1-3]. In particular, some studies have reported that PICCs may be advantageous over CICCs with respect to bloodstream infection [4,5].

However, PICCs are accompanied by various complications throughout the period from insertion to removal, including central line-associated bloodstream infection, deep vein thrombosis/venous thromboembolism, occlusion, dislodgement, malposition, and insertion-site bleeding [6-8]. In particular, a systematic review reported that the risk of venous thrombosis is relatively high compared with that of other central venous catheters [9]. These complications impose not only a physical but also a psychological and economic burden on patients [10,11], and many of them culminate in unplanned removal, in which the catheter is removed before the completion of the planned treatment [6].

Unplanned removal of a PICC is a representative patient-safety problem that leads to interruption and delay of ongoing treatment, additional risk and cost from reinsertion, secondary infection and thrombosis, and prolonged hospitalization [12,13]. Across several cohorts, PICC failure rates have been reported to reach approximately 15%–30%; a trial protocol on dressing and securement cites a failure rate of about 30% drawn from earlier work [14], and a prospective study of cancer patients reported removal-associated failure of about 15% [15]. In an adult multicenter cohort, the incidence of unplanned removal was about 10% [13,16], and early removal within 5 days of insertion reached about 19% [12]. Therefore, the early detection and prevention of these complications to ensure the catheter remains securely in place until the completion of therapy constitute a critical clinical challenge.

In this context, clinical prediction models have been actively developed to identify high-risk patients early and enable the efficient allocation of monitoring and nursing intervention

resources [17-19]. Nonetheless, existing literature reviews remain limited to individual complications [20], failing to deliver comprehensive evidence encompassing both direct catheter removal and catheter failure within the framework of catheter maintenance. Moreover, with many existing models confined to the initial development stage, the degree to which external validation and model robustness have been verified across diverse clinical environments has yet to be thoroughly examined. A comprehensive review of prediction models for unplanned catheter removal and their leading complications—while critically appraising their methodological rigor and external validation status—is essential for establishing dependable decision-support tools in clinical practice. The purpose of this review is, in adult PICC patients, to (1) examine the methodological features and performance of models predicting unplanned removal and its precipitating complications, (2) characterize the distribution of the predictors retained in these models across the patient, catheter, and treatment/management domains.

METHODS

This narrative review summarized the literature on prediction models for unplanned PICC removal and its precipitating complications in adults. PubMed and Scopus were searched between August 11 and 16, 2026, with the final search conducted on August 16, 2026. The search covered all records indexed from database inception through that date, with no restriction on publication year. Data extraction was performed by a single reviewer, and no independent cross-validation of the extracted data was conducted. Search terms included “peripherally inserted central catheter,” “PICC,” “unplanned removal,” “unplanned extubation,” “premature removal,” “early removal,” “dislodgement,” “catheter failure,” “risk factor,” “prediction model,” “predictive model,” “nomogram,” and “machine learning.” Google Scholar was also used as a supplementary search source during the same period. In addition, the reference lists of included studies and relevant reviews were manually searched to supplement the database search. (n=6,276). Records retrieved from the two databases were merged and duplicates were removed (n=787), after which 5,489 records underwent title and abstract screening.

Studies were eligible if they involved adult patients aged 18 years or older with a PICC and developed or validated a model predicting removal of the catheter—including accidental dislodgement, early or premature removal, and catheter failure—or

one of its precipitating complications such as bloodstream infection, venous thrombosis, and occlusion. Whether a study had in fact developed or validated a prediction model was determined at the screening stage rather than by the search itself. Studies that reported risk-factor associations without constructing a prediction model, reports limited to pediatric or neonatal populations, records for which only an abstract was available without accessible full text (e.g., conference abstracts), and non-research publications such as reviews, editorials, comments, and case reports were excluded (n=5,457). We then assessed whether the remaining studies had actually developed a prediction model. Studies that reported only risk factors and statistical significance without developing a prediction model were excluded (n=18). Ultimately, 14 studies were included in the review and are summarized in Table 1.

RESULTS

Fourteen prediction-model studies were included. Three took removal itself as the prediction target (direct evidence) and 11 targeted a removal-precipitating complication (indirect evidence). Characteristics of the included studies are summarized in Table 1.

Definition and incidence of unplanned removal

Across the literature, the terms denoting unplanned removal varied—unplanned removal, “unplanned extubation”, premature/early removal, dislodgement, catheter failure, and removal due to complication—and their operational definitions were inconsistent [13,16,17]. Some studies addressed only removal forced by complications, whereas others included accidental dislodgement or early removal unrelated to complications. For example, one retrospective study defined early removal as removal within 5 days of insertion for reasons other than a PICC complication [12].

Incidence also varied widely by definition and population. In an adult multicenter prospective cohort, the incidence of unplanned removal was about 10% [13], and early removal within 5 days was reported at about 19% [12]. In a prospective study of cancer patients, removal-associated PICC failure was about 15%, with reasons including upper-extremity deep vein thrombosis, bloodstream infection, exit-site infection, dislodgement, and occlusion [15]. A trial protocol on dressing and securement cites, as background rather than as its own result, a PICC failure rate of about 30% owing to vascular, infectious, or mechanical

complications [14], which indicates that unplanned removal is a common causal endpoint of these complications. Spontaneous dislodgement, when analyzed as a separate endpoint, occurred in about 4% of PICCs over 60,894 catheter-days in an oncology cohort [21]. The operational definition and the unit of observation—patient, catheter, or catheter-days—differed across studies and account for a substantial part of this variation. These incidence estimates are drawn from cohort studies cited here as background; the outcome definition, follow-up unit, and event count of every included prediction-model study are reported in Table 1.

Prediction models for unplanned removal and related complications

Fourteen studies developed or validated a prediction model (Table 1). Of these, three took removal itself as the prediction target, whereas eleven targeted a precipitating complication—most commonly venous thrombosis. Across the fourteen studies, the predictors retained in the final models were distributed over the patient, catheter, and treatment/management domains rather than concentrated in any one of them.

Models targeting removal itself

Three models took removal itself as the prediction target. One prospective study selected architectures by combining univariate analysis, least absolute shrinkage and selection operator, and multivariable analysis, adopted a support vector machine (SVM) as the final model, and is the only model in this review to have been externally validated in separate hospitals [17]. A second study combined multiple machine-learning algorithms with SHapley Additive exPlanations (SHAP)-based interpretation and proposed that a composite index combining health-related quality of life and self-management ability was the most influential predictor, emphasizing the importance of patient-driven factors beyond traditional clinical and laboratory variables [18]. A third study, in patients receiving parenteral nutrition, defined complication-induced removal as the event and applied both classification algorithms and survival-based deep learning to it [22].

All three were developed in single centers. In two of them the number of events was very small relative to the number of candidate predictors, so the headline performance figures are difficult to interpret: in one, the reported classification accuracy is close to what would be obtained by predicting no event for every patient, whereas the discrimination of the corresponding

Table 1. Characteristics of the included prediction-model studies (n=14), by outcome category

Study (ref.)	Population	Development/ validation	Events/total (unit, %)	Outcome	Candidate/ final predictors	Selection method	Final model variables	Model type	Discrimination (AUC/C-index, 95% CI)	Validation; interpretability
Models targeting removal itself (direct evidence, n=3)										
Zhang et al. (2023) [17]	Cancer patients, China	Development 3,391 (train 2,374/test 1,017); external validation 600	284/3,391 (per patient, 8.38%)	Unplanned PICC removal: early removal for a severe complication, or accidental dislodgement	33 → 10	Univariable screening, LASSO (11 variables), then multivariable backward logistic regression	Impaired physical mobility; elevated D-dimer; diabetes; surgical history; more than one puncture; surgical treatment; targeted therapy. Protective: valved catheter, normal BMI, polyurethane material	SVM (compared with logistic regression and random forest; TOPSIS used for final selection)	0.904 (train)/0.875 (test)/0.718 (external validation)	External (two hospitals) and internal; Hosmer–Lemeshow $P=0.06$; DCA reported.
Yang et al. (2026) [18]	Cancer patients, outpatient catheter-maintenance clinic, China	212 (23 events/189 non-events)	23/212 (per patient, 10.8%)	Unplanned PICC removal requiring new vascular access	30 → 13 significant on univariable screening ($P<0.100$)	Univariable screening; weight-of-evidence encoding; focal loss for class imbalance	A composite index of health-related quality of life and self-management ability ranked first by SHAP, followed by self-management score and mid-upper-arm circumference of the PICC arm	XGBoost with focal loss compared with random forest, SVM and logistic regression)	AUC 0.994; recall 0.870; accuracy 0.967; F1 0.851	Internal (stratified 5-fold CV); Brier score 0.03, calibration plot and DCA; SHAP. External validation not performed.
Lee and Park (2025) [22]	Patients receiving parenteral nutrition, Korea	218 procedures 174/test 44	18/218 (per procedure, 8.3%)	Complication-induced PICC removal (infection, occlusion, exit-site discomfort or dislodgement), analysed as time to event	10 → 10	Prespecified candidate set; no variable selection	Sex; age; cancer diagnosis; previous central venous catheter; first procedure; insertion side; insertion vein; insertion length; catheter diameter; interval from admission to request	Logistic regression, SVM, random forest and XGBoost for classification; DeepSurv, DeepHit and random survival forest for time to event	C-index: DeepSurv 0.611 (0.158–0.896); DeepHit 0.475; random survival forest 0.329. Mean classification accuracy 0.92 against an uninformative baseline of 91.7%	Internal (5-fold CV; separate test set of 44); integrated Brier score reported. External validation not performed.
Models targeting removal-precipitating complications (indirect evidence, n=11)										
Sheng and Gao (2024) [19]	Adults with PICC, single hospital catheter clinic, China	1,065 patients (80/20 split)	76/1,065 (per patient, 7.14%)	PICC-related deep vein thrombosis confirmed on Doppler ultrasound after weekly Constans score and D-dimer screening	21 → 21	None; all 21 literature-derived variables were entered	Catheter-to-vein ratio ranked first in all three algorithms (random forest importance 91.55%)	Random forest, artificial neural network, support vector classifier	RF 0.86/ANN 0.81/SVC 0.77 (mean 0.81)	Internal (10-fold CV). The reported precision, recall and accuracy take “no DVT”, the majority class in 92.86% of the sample, as the positive label.
Li et al. (2024) [23]	Adults with PICC, single municipal hospital, China	505 patients	75/505 (per patient, 14.85%)	PICC-related infection	NR → 7	LASSO followed by multivariable logistic regression	Age >60 yr; catheter movement; maintenance interval >7 days; direct puncture; impaired immunity; concurrent complication; pre-insertion temperature ≥ 37.2 °C	Logistic regression/nomogram	0.889	Internal. Several odds ratios lie close to the lower confidence limit, so internal reporting consistency is uncertain.

(Continued to the next page)

Table 1. Continued

Study (ref.)	Population	Development/ validation	Events/total (unit, %)	Outcome	Candidate/ final predictors	Selection method	Final model variables	Model type	Discrimination (AUC/C-index, 95% CI)	Validation; interpretability
Song et al. (2020) [24]	Cancer patients on a first PICC for chemotherapy, China	339 patients	59/339 (per patient, 17.4%)	PICC-associated thrombosis on routine ultrasound 2 weeks after insertion; 96.6% asymptomatic and 93.2% fibrin sleeve	NR → 4	Fisher scoring followed by multivariable logistic regression	Performance status; number of lumens; D-dimer; height (protective). Catheter-to-vein ratio was significant on univariable testing only and was explicitly excluded by the authors.	Logistic regression/nomogram	0.822±0.031 for the best five-variable combination; 0.780±0.033 for the two-variable model the authors designated as best	No validation (apparent performance only; no split, cross-validation or bootstrap).
Chopra et al. (2017) [25]	Hospitalised adults on general medicine wards or in ICU, 51-hospital consortium, USA	23,010 patients	475/23,010 (per patient, 2.1%)	Symptomatic, imaging-confirmed upper extremity deep vein thrombosis; imaging was performed only when symptoms were present	NR → 5	Univariable mixed-effects screening ($P \leq 0.10$) then stepwise selection by the Schwarz criterion; 10-fold multiple imputation	Another central venous catheter (1 point); WBC >12,000 (1 point); active cancer (2 points); two lumens (2 points) or three to four lumens (3 points); venous thromboembolism history (2 points) or within 30 days (3 points)	Point-based risk score derived from a logistic mixed model	0.71 for the mixed model (estimated optimism 0.04); 0.65 on marginal predicted probability (optimism 0.03)	Internal only (200 bootstrap replications; calibration intercept 0.35, slope 0.90 [0.78–1.14]). External validation was not performed in this study.
Xia et al. (2026) [26]	Critically ill adults, MIMIC-IV database, USA	8,145 insertions/6,376 patients (train 6,516/test 1,629)	1,375/8,145 (per insertion, 16.88%)	PICC-associated thrombotic complications identified from ICD-9 and ICD-10 codes during the same hospitalisation	29 → 29	Prespecified candidate set; no selection. SMOTE was applied to the training set only, after the split.	All 29 variables retained. Prior thrombosis history was dominant (Gini importance 0.138), followed by INR (0.067). No catheter variables were available in the database.	Random forest (compared with logistic regression, SVM, gradient boosting and XGBoost)	0.809 (0.780–0.838); 0.696 under patient-clustered splitting; 0.717 restricted to each patient's first PICC	Internal (5-fold CV; bootstrap CI; DeLong test). TRIPOD+AI checklist reported; Gini importance and SHAP. External validation not performed.
Su et al. (2026) [27]	Patients with haematological malignancies, multicentre, China	4,015 (train 2,810/independent test 1,205)	232/4,015 (per patient, 5.8%)	Symptomatic PICC-related thrombosis	NR → 9, of which 5 were independent predictors	LASSO	History of venous thromboembolism; triple-lumen catheter; immunomodulatory drug use; peak D-dimer (risk rising sharply above about 1.5 mg/L); peak neutrophil-to-lymphocyte ratio	XGBoost (compared with a logistic regression baseline)	0.862 (0.825–0.899) in the independent test set	Independent test set; SHAP; open web calculator. Negative predictive value 98.6% and positive predictive value 18.8%
Cui et al. (2026) [28]	Patients with gastrointestinal malignancies undergoing interventional therapy, China	782 patients	74/782 (per patient, cumulative incidence 7.8% at 1 month and 9.2% at 3 months)	Symptomatic PICC-related venous thrombosis, with death and non-thrombotic unplanned removal treated as competing events	7 → 4	Fine-Gray sub-distribution regression with AIC-based backward elimination	Catheter-to-vein ratio >0.45; non-cavoatrial tip position; elevated baseline D-dimer; neutrophil-to-lymphocyte ratio ≥3.0	Competing-risk nomogram	C-index 0.75	Internal (1,000 bootstrap replications); calibration curves at 1, 2 and 3 months

(Continued to the next page)

Table 1. Continued

Study (ref.)	Population	Development/ validation	Events/total (unit, %)	Outcome	Candidate/ final predictors	Selection method	Final model variables	Model type	Discrimination (AUC/C-index, 95% CI)	Validation; interpretability
Guo et al. (2025) [29]	Patients with haematological malignancies, single tertiary centre, China	764 (train 534/validation 230)	46/764 (per patient, 6.02%)	PICC catheter-related bloodstream infection (concurrent peripheral catheter-tip cultures, or differential time to positivity)	18 → 9	LASSO with 10-fold CV then stepwise multivariable logistic regression, both fitted on SMOTE-NC-augmented training data	Diabetes history; age; dwell time>60 days; two or more insertion attempts; dual-lumen catheter; cephalic vein; absolute neutrophil count<1.5x10 ⁹ /L; absolute lymphocyte count<1.0x10 ⁹ /L; D-dimer≥0.5 mg/L	Logistic regression/nomogram	0.883 (0.863–0.903) in training and 0.822 (0.719–0.924) in validation	Internal validation set; calibration with bootstrap resampling; DCA. Estimates and training discrimination derive from oversampled data
Li et al. (2025) [31]	Adults with PICC, 27 hospitals, China	3,453 patients (train 2,764/test 691)	525/3,453 (per patient, 15.2%), of which 401 (76.4%) led to catheter removal	PICC-related venous thrombosis as time to event (symptoms combined with ultrasound findings)	About 48 → 26 (a 16-variable model was also built)	Univariable logistic screening carried out on the whole data set before the train–test split	Two prespecified sets of 26 and 16 variables	DeepSurv, DeepHit and Cox-Time; MP-RSF, MP-Ad-aBoost, ThresReg and MP-LogitR	26-variable C-index: DeepSurv 0.95, Cox-Time 0.949, DeepHit aBoost, versus 0.707–0.772 for the conventional algorithms. The same DeepSurv model falls to 0.759 with 16 variables	Internal (5-fold CV); integrated Brier score; intraclass correlation for stability
Gao et al. (2025) [32]	Adult cancer inpatients, single cancer hospital, China	20,941 patients (train 14,659/validation 6,282)	227/20,941 (per patient, 1.1%)	Catheter occlusion, defined as inability to flush with saline or to aspirate blood	More than 90 → 59 → 13	LASSO (λ=0.001067, 10-fold CV)	Catheter type; insertion length; dwell days; sex; electrolyte disturbance; primary tumour site; thrombophilia; cough; malnutrition; number of insertion attempts; number of chemotherapy agents; herbal medicine; interleukin	XGBoost (compared with logistic regression and random forest)	Training: RF 0.976/XGBoost 0.929/logistic 0.786. Validation: logistic 0.773/XGBoost 0.759/RF 0.643	Internal; SHAP. Logistic regression outperformed both tree ensembles in validation, yet XGBoost was declared the optimal model.
Hu et al. (2025) [30]	Cancer patients, prospective cohort, China	281 enrolled/275 analysed	18/275 (per patient, 6.5%)	Symptomatic PICC-related venous thrombosis	NR → 4	Univariable screening then stepwise multivariable logistic regression	Insulin-requiring diabetes 8.016 (1.157–55.536); major surgery; reduced limb activity of the PICC arm; catheter material	Logistic regression/nomogram	0.796 (0.695–0.897)	Internal; Hosmer–Lemeshow 1.685, P=0.194. External validation not performed.

Not-reported items are entered as NR. In [26] the primary estimate of 0.809 falls to 0.696 when the data are split by patient rather than by insertion, indicating that part of the apparent discrimination reflects repeated insertions in the same patient. In [29] both variable selection and model fitting were carried out on SMOTE-NC-augmented training data, so the reported precision is optimistic relative to the 46 observed events. In [31] variable selection preceded the train–test split. In [24] no form of internal validation was reported. In [19] the reported precision, recall and accuracy take the majority class as the positive label. In [22] the mean classification accuracy of 0.92 is indistinguishable from the uninformative baseline of 91.7% implied by an event rate of 8.3%.

AIC, Akaike information criterion; ANN, artificial neural network; AUC, area under the curve; BMI, body mass index; CI, confidence interval; CV, cross-validation; DCA, decision curve analysis; DVT, deep vein thrombosis; ICD, International Classification of Diseases; ICU, intensive care unit; INR, international normalised ratio; LASSO, least absolute shrinkage and selection operator; MIMIC, Medical Information Mart for Intensive Care; NR, not reported; PICC, peripherally inserted central catheter; ref., reference; RF, random forest; SHAP, SHapley Additive exPlanations; SMOTE, synthetic minority over-sampling technique; SMOTE-NC, SMOTE for nominal and continuous features; SVC, support vector classifier; SVM, support vector machine; TOPSIS, technique for order of preference by similarity to ideal solution; TRIPOD, transparent reporting of a multivariable prediction model for individual prognosis or diagnosis; WBC, white blood cell.

time-to-event model was substantially lower and its confidence interval very wide [18,22]. The number of models targeting removal has therefore increased, but the evidence supporting them has not.

The predictors retained in these three models were concentrated in the patient and catheter domains, with little overlap between them. In the patient domain, impaired physical mobility, elevated D-dimer, diabetes, and a history of surgery were retained in the externally validated model [17], whereas the model developed in an outpatient catheter-maintenance clinic retained a composite index of health-related quality of life and self-management ability as its most influential variable by SHAP, followed by the self-management score itself and the mid-upper-arm circumference of the PICC-bearing arm [18]; sex, age, cancer diagnosis, and a previous central venous catheter were prespecified in the parenteral-nutrition model [22]. In the catheter domain, the retained variables described the insertion procedure as much as the device: more than one puncture attempt increased risk, whereas a valved catheter, a normal body mass index, and polyurethane material were protective [17], and insertion side, insertion vein, insertion length, catheter diameter, and whether the procedure was the first were entered without variable selection [22]. Treatment- and management-related predictors were limited to surgical treatment, targeted therapy [17], and the interval from admission to the insertion request [22]. Notably, none of the three models retained the number of catheter lumens, and D-dimer was the only laboratory marker retained in any of them.

Models targeting removal-precipitating complications

Many traditional prediction studies used logistic regression and nomograms to predict PICC-related bloodstream infection or venous thrombosis [23,24]. Representatively, the Michigan Risk Score predicts PICC-related thrombosis using a five-variable scoring system—presence of another central venous catheter, leukocytosis, multi-lumen PICC, a history of deep vein thrombosis, and active cancer—and was internally validated by bootstrap resampling, with external validation left to subsequent work [25]. Machine-learning studies compared various algorithms, including logistic regression, SVM, random forests, and gradient boosting; one such study combined patient features and catheterization-technology features to predict PICC-related deep vein thrombosis [19].

Modeling approaches in this group have diversified rapidly in recent years. Reported developments include machine-learning

models built on a large intensive-care database and reported in accordance with TRIPOD+AI [26]; a dynamic multicentre model with an independent test set in patients with haematological malignancies [27]; a competing-risk nomogram in which non-thrombotic unplanned removal and death were explicitly treated as competing events [28]; nomograms for catheter-related bloodstream infection [29] and prospectively derived models for symptomatic thrombosis [30]; survival-based deep-learning models [31]; and gradient-boosting models for catheter occlusion with SHAP-based interpretation [32].

Across the eleven models targeting a precipitating complication, coagulation and inflammatory markers were the predictors retained most frequently. An elevated D-dimer was retained in models of thrombosis and of bloodstream infection alike [24,27-29], and the neutrophil-to-lymphocyte ratio, leukocytosis, and absolute neutrophil and lymphocyte counts were retained in several others [25,27-29]. A history of venous thromboembolism recurred repeatedly and was the dominant variable in the intensive-care model, in which prior thrombosis carried the highest importance and the international normalised ratio ranked second [25,26,27]. Older age, diabetes, active malignancy, and impaired immunity were retained across outcome types [23,25,29,30], as were disease- and nutrition-related characteristics such as performance status, primary tumour site, thrombophilia, and malnutrition [24,32]. Functional and patient-reported characteristics appeared only once, as reduced activity of the catheter-bearing limb [30].

In the catheter domain, the number of lumens was the most consistently retained predictor, with multi-lumen catheters carrying increased risk in models of bloodstream infection and of thrombosis [24,25,27,29] and with a graded effect in the Michigan Risk Score, which scored two lumens and three to four lumens separately rather than dichotomizing them [25]. The catheter-to-vein ratio ranked first among all variables in one machine-learning model and was retained as a dichotomized threshold above 0.45 in a competing-risk nomogram [19,28], yet another nomogram excluded it explicitly despite univariable significance [24]. Tip position, insertion vein, insertion length, dwell time, and the number of puncture attempts were retained in several models [28,29,32], whereas catheter material and catheter type entered without a comparable reference category or directional interpretation [30,32]. The largest database-derived model contained no catheter variables at all, because none were recorded in the source database [26]. Treatment- and management-related predictors were fewer and were con-

centrated in the models of infection and of occlusion: catheter movement, a maintenance interval longer than 7 days, direct puncture, and a pre-insertion temperature of 37.2 °C or higher [23]; the number of chemotherapy agents and herbal medicine use [32]; immunomodulatory drug use [27]; and recent major surgery [30]. These management variables were retained less frequently than laboratory values and were operationalized inconsistently across studies.

Model performance, validation, and interpretability

The discrimination of the included models was generally in the range of 0.7–0.9 by area under the curve (AUC) or concordance index (C-index), and some models also presented calibration and decision-curve-analysis results [23–25]. However, external validation in a separate cohort was performed in only one study [17], and many had limitations such as single-center, retrospective designs, small samples, and an insufficient number of events per variable. Although the adoption of interpretability techniques such as SHAP has recently increased [18], the completeness of reporting remained limited, with sensitivity and specificity often not reported. More recent studies show partial improvement—explicit adherence to reporting guidance for prediction models [26], prespecified predictors with bootstrap internal validation [28], and independent test sets [27]—but external validation in a separate cohort remains uncommon, and this improvement has occurred almost entirely among models targeting complications rather than removal.

DISCUSSION

In this study, we confirmed that unplanned removal of PICCs is not a single event but a complex event to which heterogeneous complications—venous thrombosis, bloodstream infection, dislodgement, and occlusion—commonly converge [6,15,16]. For this reason, the predictors retained in models of unplanned removal and its precipitating complications are also distributed in a complex manner across the patient, catheter, and treatment domains, and prediction research has tended to focus on the individual precipitating complications rather than on removal itself.

This distinction has direct implications for the interpretation of the evidence. Predictors derived from models of thrombosis or bloodstream infection identify patients at risk of developing a complication, but they do not necessarily identify patients whose catheter will be removed, because whether a complica-

tion leads to removal depends further on institutional protocols, clinician judgment, and the availability of alternative venous access. Models targeting precipitating complications should therefore be regarded as indirect surrogates rather than as direct evidence for unplanned removal. One recent competing-risk analysis makes this separation explicit by treating non-thrombotic unplanned removal as a competing event rather than as censoring [28].

Among the predictors retained in the included models, the number of catheter lumens was the most consistent: a higher number of lumens was associated with greater risk in models of bloodstream infection and of thrombosis, across different populations and outcome definitions [24,25,27,29], and the same pattern is reported in cohort studies of unplanned removal [13] and of its precipitating complications [20,33]. Elevated D-dimer, a history of venous thromboembolism, older age, diabetes, and active malignancy were likewise retained repeatedly [17,24–27,29]. By contrast, several widely cited factors were not consistent. Catheter material and valve type entered the models with different reference categories and opposite directions across populations and catheter products [17,30,32], and the same instability is evident in the large multicenter cohorts from which candidate variables are commonly drawn [13,16,34]. The insertion side was not retained in any of the models reviewed here and showed no association in the cohort studies that used symptomatic, imaging-confirmed thrombosis as a single endpoint [25,34–36]. Dwell time was retained as a predictor in some models [29,32] but was unrelated to any complication in one prospective cohort [8] and was assessed without multivariable adjustment in another [37]. Much of this inconsistency arises from differences in outcome definitions and in the covariate sets entering variable selection, which together act as a fundamental constraint that hampers the comparison and integration of predictors across models.

In addition, prediction-model studies of unplanned PICC removal revealed several common limitations. First, the heterogeneity of outcomes is prominent. Because many models conflate removal with its precipitating complications such as thrombosis and infection, models that directly predict removal itself remain few [17,18,22], and only one of them has been externally validated [17]. Adding the recently published studies raised this number only from two to three; all the other newly identified models targeted thrombosis, bloodstream infection, or occlusion [26–32]. The more consequential limitation is therefore not the count but the evidence behind it: all three removal-targeting

models were developed in single centers, and only one has been tested outside its development setting. Second, the risk of methodological bias is high. Retrospective designs, small samples, an insufficient number of events per variable, arbitrary categorization of continuous variables, the absence of external validation, and non-reporting of sensitivity and specificity are repeatedly observed [19,23,24]. The heterogeneity of variable selection compounds this: because candidate sets and reduction methods differed so widely across studies, and in one case selection preceded the train-test split, the retained predictors partly reflect the analytic pipeline rather than the underlying clinical mechanism. Third, these problems ultimately limit the reproducibility and generalizability of the models.

The clinical value of such predictors and prediction models is realized only when they are linked to monitoring. Stratifying patients by risk allows monitoring resources to be allocated in proportion to the level of risk. That is, risk-based and targeted monitoring becomes possible—applying intensive monitoring, such as insertion-site inspection, dressing checks, symptom screening, and ultrasound surveillance where necessary, to high-risk patients, and relatively light monitoring to low-risk patients. This represents a shift away from a reactive approach that responds only after a complication has occurred, toward proactive care that detects complications early, before they lead to removal.

Furthermore, such monitoring may support a more individualized and patient-centered approach when it is tailored to each patient's risk profile. For example, thrombosis surveillance may be prioritized for patients with cancer, elevated D-dimer levels, or multi-lumen catheters, whereas monitoring for dislodgement and related education may be emphasized in patients with limited physical activity or low self-management ability. In particular, the finding that a composite index combining quality of life and self-management ability was a strong predictor of unplanned removal [18] suggests that monitoring strategies should consider not only clinical and laboratory variables but also patient-reported outcomes and functional characteristics [10].

In this context, nursing practice represents an important point of integration for risk-based monitoring because nurses are closely involved in routine post-insertion assessment, including observation of the insertion site, dressing condition, catheter patency, symptom changes, and patient education. Prediction models may therefore have potential value in supporting more individualized monitoring within routine care.

However, whether such models can be effectively incorporated into clinical nursing workflows, and whether their use improves monitoring processes or patient-related outcomes, remains to be established. Future implementation and impact studies are needed to evaluate their feasibility, acceptability, workflow integration, and clinical utility in real-world practice.

Limitations

This review has several limitations. First, the review was restricted to two bibliographic databases and to English-language publications. Second, screening and data extraction were performed by one reviewer, the review was not prospectively registered, and a formal risk-of-bias assessment such as PROBAST was not conducted. Third, marked heterogeneity in outcome definitions, populations, and analytic approaches precluded quantitative synthesis, so all findings are presented descriptively and no ranking of predictors or models by strength of evidence is implied.

Conclusion

Unplanned removal of PICCs is an important clinical problem that threatens treatment continuity and patient safety, and the predictors retained in existing models are distributed multidimensionally across the patient, catheter, and treatment/management domains. Current prediction research is concentrated mainly on the individual precipitating complications, such as venous thrombosis and bloodstream infection, and studies that directly predict and externally validate removal itself remain few. Integrating prediction- and risk-factor-based monitoring into the nursing workflow represents a plausible next step, but no included study evaluated its effect on patient outcomes, and whether such integration reduces unplanned removal remains to be demonstrated. Future work should prioritize standardized outcome definitions; prospective, multicenter studies with adequate event numbers; externally validated and interpretable models that take removal itself as the prediction target; and implementation studies evaluating model-guided nursing monitoring against removal-related outcomes.

ORCID

Seon Min LEE, <https://orcid.org/0009-0004-8694-2169>

Jeong Yun PARK, <https://orcid.org/0000-0002-0210-8213>

AUTHOR CONTRIBUTIONS

Dr. Jeong Yun PARK had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: SML and JYP. Data curation: SML. Formal analysis: SML and JYP. Investigation: SML. Methodology: SML and JYP. Software: SML. Validation: SML and JYP. Writing—original draft: SML. Writing—review & editing: JYP.

CONFLICTS OF INTEREST

Jeong Yun PARK is the Ethics Editor of this journal and was not involved in the peer review or editorial decision-making process for this article. No other potential conflicts of interest relevant to this article were reported.

FUNDING

The study was conducted with the support of the 2023 Health Fellowship Foundation.

DATA AVAILABILITY

The data presented in this study are available upon reasonable request from the corresponding author.

REFERENCES

1. Santos FKY, Flumignan RLG, Areias LL, Sarpe AKP, Amaral FCF, Ávila RB, et al. Peripherally inserted central catheter versus central venous catheter for intravenous access: a protocol for systematic review and meta-analysis. *Medicine (Baltimore)* 2020;99(30):e20352.
2. Lai JY, Wu MJ, Gautama MSN, Huang TW. Comparison of complication rates between midline catheters and peripherally inserted central catheters: a systematic review and meta-analysis of randomized controlled trials. *J Hosp Infect* 2024;151:131-9.
3. Swaminathan L, Flanders S, Horowitz J, Zhang Q, O'Malley M, Chopra V. Safety and outcomes of midline catheters vs peripherally inserted central catheters for patients with short-term indications: a multicenter study. *JAMA Intern Med* 2022;182(1):50-8.
4. Pitiriga V, Bakalis J, Theodoridou K, Kanellopoulos P, Saroglou G, Tsakris A. Lower risk of bloodstream infections for peripherally inserted central catheters compared to central venous catheters in critically ill patients. *Antimicrob Resist Infect Control* 2022;11(1):137.
5. Nakaya Y, Imasaki M, Shirano M, Shimizu K, Yagi N, Tsutsumi M, et al. Peripherally inserted central venous catheters decrease central line-associated bloodstream infections and change microbiological epidemiology in adult hematology unit: a propensity score-adjusted analysis. *Ann Hematol* 2022;101(9):2069-77.
6. Kalma B, van Zundert A. Perils of the PICC: peripherally inserted central catheter-associated complications and recommendations for prevention in clinical practice: a narrative review. *Healthcare (Basel)* 2025;13(16):1993.
7. Liu R, Xu H, Pu L, Xie X, Chen H, Wu Z, et al. Clinical characteristics of peripherally inserted central catheter-related complications in cancer patients undergoing chemotherapy: a prospective and observational study. *BMC Cancer* 2023;23(1):894.
8. Grau D, Clarivet B, Lotthé A, Bommart S, Parer S. Complications with peripherally inserted central catheters (PICCs) used in hospitalized patients and outpatients: a prospective cohort study. *Antimicrob Resist Infect Control* 2017;6:18.
9. Chopra V, Anand S, Hickner A, Buist M, Rogers MA, Saint S, et al. Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. *Lancet* 2013;382(9889):311-25.
10. Krein SL, Saint S, Trautner BW, Kuhn L, Colozzi J, Ratz D, et al. Patient-reported complications related to peripherally inserted central catheters: a multicentre prospective cohort study. *BMJ Qual Saf* 2019;28(7):574-81.
11. Comas M, Domingo L, Jansana A, Lafuente E, Civit A, García-Pérez L, et al. Cost-effectiveness analysis of peripherally inserted central catheters versus central venous catheters for in-hospital parenteral nutrition. *J Patient Saf* 2022;18(7):e1109-15.
12. Shen BH, Mahoney L, Molino J, Mermel LA. Risk factors for early PICC removal: a retrospective study of adult inpatients at an academic medical center. *PLoS One* 2022;17(7):e0264245.
13. Liu Y, Huo X, Zhang D, Liu Y, Ge R, Zhang J, et al. The incidence and risk factors of unplanned removal of peripherally inserted central catheters among adult patients: a multi-centre cohort study. *J Clin Nurs* 2024;33(2):580-90.
14. Rickard CM, Marsh NM, Webster J, Gavin NC, Chan RJ, McCarthy AL, et al. Peripherally Inserted Central catheter dressing and securement in patients with cancer: the PISCES trial. Protocol for a 2x2 factorial, superiority randomised controlled trial. *BMJ Open* 2017;7(6):e015291.
15. Bertoglio S, Faccini B, Lalli L, Cafiero F, Bruzzi P. Peripherally

- inserted central catheters (PICCs) in cancer patients under chemotherapy: a prospective study on the incidence of complications and overall failures. *J Surg Oncol* 2016;113(6):708-14.
16. Yu K, Li J, Zhang D, Liu B, Wang K, Liu W, et al. Types of peripherally inserted central catheters and the risk of unplanned removals in patients: a prospective cohort study. *Int J Nurs Stud* 2024;149:104621.
 17. Zhang J, Ma G, Peng S, Hou J, Xu R, Luo L, et al. Risk factors and predictive models for peripherally inserted central catheter unplanned extubation in patients with cancer: prospective, machine learning study. *J Med Internet Res* 2023;25:e49016.
 18. Yang Y, Yang Y, Liu Q, Li C, Long Y, Li X, et al. Interpretable machine-learning risk prediction of unplanned extubation among cancer patients with peripherally inserted central catheters. *Sci Rep* 2026;16(1):7311.
 19. Sheng Y, Gao W. Machine learning predicts peripherally inserted central catheters-related deep vein thrombosis using patient features and catheterization technology features. *Clin Nurs Res* 2024;33(6):460-9.
 20. Song Y, Liu S, Lou T, Ma Y, Wang N, Yong Q, et al. Risk factors associated with peripherally inserted central catheter-related venous thrombosis in hospitalized patients of advanced age. *J Int Med Res* 2020;48(1):300060518820744.
 21. Qiu XX, Guo Y, Fan HB, Shao J, Zhang XB. Incidence, risk factors and clinical outcomes of peripherally inserted central catheter spontaneous dislodgment in oncology patients: a prospective cohort study. *Int J Nurs Stud* 2014;51(7):955-63.
 22. Lee SM, Park J. Risk factors for complications associated with peripherally inserted central venous catheters for parenteral nutrition: machine learning and survival analysis based on deep learning. *Clin Nutr* 2025;55:249-56.
 23. Li W, Cao J, Du YL, Wen YD, Luo WX, Liu XY. Risk factors and prediction model construction for peripherally inserted central catheter-related infections. *Heliyon* 2024;10(8):e29158.
 24. Song X, Lu H, Chen F, Bao Z, Li S, Li S, et al. A longitudinal observational retrospective study on risk factors and predictive model of PICC associated thrombosis in cancer patients. *Sci Rep* 2020;10(1):10090.
 25. Chopra V, Kaatz S, Conlon A, Paje D, Grant PJ, Rogers MAM, et al. The Michigan Risk Score to predict peripherally inserted central catheter-associated thrombosis. *J Thromb Haemost* 2017;15(10):1951-62.
 26. Xia L, Jiang H, Zhang Y, Guo J, Sun M, Wu H, et al. Machine learning prediction of PICC-associated thrombotic complications in critically ill patients. *BMC Med Inform Decis Mak* 2026;26(1):287.
 27. Su J, Hu J, Wang W, Lai Z, Su J, Wu Y. Machine learning-based prediction of peripherally inserted central catheter-related thrombosis in hematological malignancies: development and validation of a dynamic model in a multicenter cohort. *Support Care Cancer* 2026;34(9):875.
 28. Cui T, Li J, Chen W, Hou Y, Lv H. Development and validation of a competing risk nomogram for predicting PICC-related venous thrombosis in patients with gastrointestinal malignancies. *Front Oncol* 2026;16:1822555.
 29. Guo Q, Liu Y, Zhu X, Gao Y, Zhou Y, Zhang X. Development and validation of a nomogram for predicting PICC catheter-related bloodstream infection among patients with hematologic malignancies. *BMC Infect Dis* 2025;25(1):1370.
 30. Hu Z, Luo M, He R, Wu Z, Fan Y, Li J. Development and validation of a risk prediction model for PICC-related venous thrombosis in patients with cancer: a prospective cohort study. *Sci Rep* 2025;15(1):4654.
 31. Li Y, Nie S, Wang L, Li D, Ma S, Li T, et al. Integrating deep learning in public health: a novel approach to PICC-RVT risk assessment. *Front Public Health* 2025;12:1445425.
 32. Gao L, Feng J, Gao Y, Luo L, Jiang H, Yang Q, et al. XGBoost-based model for predicting PICC occlusion risk in cancer patients: insights from SHAP analysis. *Alex Eng J* 2025;123:436-47.
 33. Chopra V, Ratz D, Kuhn L, Lopus T, Chenoweth C, Krein S. PICC-associated bloodstream infections: prevalence, patterns, and predictors. *Am J Med* 2014;127(4):319-28.
 34. Campagna S, Gonella S, Berchiolla P, Morano G, Rigo C, Zerla PA, et al. Can peripherally inserted central catheters be safely placed in patients with cancer receiving chemotherapy? A retrospective study of almost 400,000 catheter-days. *Oncologist* 2019;24(9):e953-9.
 35. Wang P, He L, Yuan Q, Lu J, Ji Q, Peng A, et al. Risk factors for peripherally inserted central catheter-related venous thrombosis in adult patients with cancer. *Thromb J* 2024;22(1):6.
 36. Paquet F, Boucher LM, Valenti D, Lindsay R. Impact of arm selection on the incidence of PICC complications: results of a randomized controlled trial. *J Vasc Access* 2017;18(5):408-14.
 37. Park S, Moon S, Pai H, Kim B. Appropriate duration of peripherally inserted central catheter maintenance to prevent central line-associated bloodstream infection. *PLoS One* 2020;15(6):e0234966.

Factors Associated with Current E-Cigarettes Use of Female Workers: Using the 2023 Community Health Survey

Eungyeong KIM, PhD, RN

School of Nursing, Kunsan National University, Gunsan, Korea

ABSTRACT

Background: The use of e-cigarettes has emerged as a growing public health concern, particularly among females. This study aimed to identify factors associated with e-cigarette use among female workers in Korea.

Methods: A secondary data analysis was conducted using representative data from the 2023 Community Health Survey. A final complete-case sample of 70,511 female workers was included in the analysis. Sociodemographic characteristics, health-related behaviors, and psychological factors associated with current e-cigarette use were identified using complex-samples binary logistic regression analysis.

Results: Compared with females aged ≥ 40 years, the odds of current e-cigarette use were higher among females aged 19–29 years (odds ratio [OR]=5.58, 95% confidence interval [CI]=4.42–7.03) and 30–39 years (OR=4.28, 95% CI=3.46–5.30). Single females had higher odds of e-cigarette use than married females (OR=2.07, 95% CI=1.73–2.48). Higher odds were also observed among females reporting stress (OR=1.42, 95% CI=1.12–1.78), depressive symptoms (OR=2.26, 95% CI=1.88–2.71), breakfast consumption < 3 times/wk (OR=2.18, 95% CI=1.85–2.56), and current alcohol use (OR=2.29, 95% CI=1.94–2.71). Females who were aware of smoke-free areas had lower odds of current e-cigarette use than those who were unaware (OR=0.58, 95% CI=0.49–0.65).

Conclusions: Among Korean female workers, e-cigarette use was significantly associated with younger age, single marital status, psychological distress, and alcohol use. Workplace health promotion and targeted interventions addressing these risk factors may help reduce e-cigarette use among female workers.

Keywords: Electronic nicotine delivery systems, Working women, Health surveys, Logistic models, Sampling studies, Cross-sectional studies

INTRODUCTION

Tobacco smoking remains a leading cause of preventable morbidity and mortality worldwide. It is a major risk factor for cardiovascular and cerebrovascular diseases, chronic obstructive pulmonary disease, lower respiratory infections, tuberculosis, and multiple cancers [1]. Despite continuing tobacco-control

efforts, tobacco use remains an important public-health concern in Korea. According to the 2022 Korea National Health and Nutrition Examination Survey, the current smoking rate among Korean adults was 17.7%, with a marked sex disparity (males, 30.0%; females, 5.0%) [2]. Alternative nicotine products have also become increasingly visible. National data reported that liquid-type e-cigarette use among adults increased from 1.1% in

Received: July 22, 2026; **Revised:** September 11, 2026; **Accepted:** September 17, 2026

Corresponding author: Eungyeong KIM, PhD, RN

School of Nursing, Kunsan National University, 558 Daehak-ro, Gunsan 54150 Korea
Tel: +82-63-469-1994 Fax: +82-63-469-7429 E-mail: egkim@kunsan.ac.kr

2013 to 4.5% in 2023, whereas heated tobacco products (HTPs) use changed from 6.2% in 2019 to 6.1% in 2023, indicating a slight decrease or relative stability rather than an increase [3]. E-cigarette aerosols and emissions contain toxicants associated with airway inflammation and cardiovascular risks [4,5], and dual use with conventional cigarettes further complicates cessation [6,7].

Despite growing attention to novel tobacco products, evidence regarding e-cigarette use specifically among employed female workers remains limited. Female workers represent a distinct demographic whose health behaviors are uniquely shaped by workplace environments, occupational stress, and socio-behavioral dynamics [8-12]. Furthermore, female smoking in Korea is frequently underreported due to social stigma, masking the true burden of nicotine reliance in this population [2]. A recent study using the same 2023 Community Health Survey (CHS) examined e-cigarette use among females of childbearing age, identifying employment as a significant risk factor [13]. However, that study encompassed a broad population including non-female workers, limiting specific insights into the working population [13]. By focusing exclusively on economically active females, the present study builds upon these findings to isolate population-specific determinants within the female workforce. Therefore, this study aimed to identify the sociodemographic, psychological, and health-related behavioral factors associated with current e-cigarette use among Korean female workers using representative data from the 2023 CHS.

METHODS

Material

The data for this study were drawn from the 2023 CHS. Established in 2008, the CHS aims to provide comparable regional health statistics and support the planning and evaluation of local public health policies. Conducted annually across all 253 administrative districts in Korea (including cities, counties, and districts), the survey samples approximately 900 individuals per district using a probability proportional to size method to select survey areas. Within each area, households are selected through systematic sampling, and all adults aged 19 years and older in the selected households are surveyed. Data collection took place between May 16 and July 31, 2023, via one-on-one computer-assisted personal interviews conducted by trained interviewers using laptops with the survey program. A total of 231,752 adults participated in the 2023 CHS. Among them, 125,998

were females. In this study, “female workers” were operationally defined as females who responded “yes” to the CHS item assessing economic activity status. Based on this criterion, an initial analytical sample of 70,552 females was identified. Item-specific missing values were observed for marital status ($n=11$), educational attainment ($n=28$), and depressive symptoms ($n=3$). Because some participants had missing data across multiple variables, a total of 41 unique cases were excluded from the multivariable analysis. Missing values were not imputed, and a complete-case analysis approach was applied. Consequently, the final complex-sample logistic regression analysis included 70,511 participants.

Measures

E-cigarette use

In this study, current e-cigarette use was defined as current use of HTPs, including daily or occasional use, and/or use of nicotine-containing liquid-type e-cigarettes on at least 1 day during the past 30 days. Participants who reported either type of use were classified as current users (coded 1), whereas those who reported neither type were classified as non-users (coded 0). The CHS includes separate items for current e-cigarette use, current HTPs use, and use of nicotine-containing liquid-type e-cigarettes during the past month. In the present study, the current HTP-use item and the nicotine-containing liquid-type e-cigarette item were combined to create a single binary outcome variable. Accordingly, the term “current e-cigarette use” in this study refers to the combined current use of HTPs and/or nicotine-containing liquid-type e-cigarettes, rather than to liquid-type e-cigarette use alone. Product-specific use and dual use were not analyzed separately.

Demographic characteristics

Demographic characteristics included age, marital status, and education level. Age was categorized into three groups: 19–29, 30–39, and 40 years or older. Marital status was classified as married or single, and education level was divided into two groups: high school or lower and more than high school.

Health-related characteristics

Health-related characteristics included subjective health status, stress, depressive symptoms, breakfast consumption, current drinking, and awareness of smoke-free areas. These variables were selected based on previous research examining men-

tal-health comorbidity and e-cigarette use [10], health-related behaviors [11], and dietary and smoking-related behaviors [13,14]. The variables were intended to represent complementary domains of perceived health, psychological well-being, daily routine, substance-use behavior, and awareness of tobacco-control policies. Subjective health status was assessed with the question, “How do you perceive your overall health?” Responses were grouped as good (very good, good), moderate (average), and poor (poor, very poor). Stress and depression were dichotomized as “yes” or “no.” Stress was measured using the responses “I feel very much,” “I feel a lot,” “I feel a little,” and “I hardly feel.” For the present analysis, “I feel very much” and “I feel a lot” were combined and coded as “yes,” whereas “I feel a little” and “I hardly feel” were combined and coded as “no.” Depression was assessed with the question, “Have you ever felt sadness or hopelessness that interfered with your daily life for two or more consecutive weeks in the past 12 months?” Breakfast consumption was assessed using the question, “On how many days during the past week did you eat breakfast?” Consistent with the categorization used in our previous study [13], responses were categorized as <3 days per week and ≥3 days per week. This cut-off was retained to ensure methodological consistency and comparability across studies. However, the ≥3 days-per-week category represents an operational definition used in the present study and should not be interpreted as a universally validated definition of regular breakfast consumption. Therefore, the term “breakfast consumption ≥3 days per week” was used throughout the manuscript instead of “regular breakfast consumption.” Current drinking was defined as consuming alcohol at least once per month over the past year. Awareness of smoke-free areas was assessed using the question, “Do you know that this area is designated as a smoke-free area?” The response options were “I know that it is designated and know the specific area” and “I know that it is designated, but do not know the specific area.” Participants who selected either of these responses were classified as being aware of smoke-free areas. Participants who answered that they did not know that the area was designated as smoke-free were classified as unaware. In this item, “this area” refers to the area specified in the 2023 CHS questionnaire.

Data analysis

Data were analyzed using IBM SPSS Statistics version 21.0 (IBM Corp.). All analyses accounted for the complex sampling design of the Korea CHS. The individual sampling weight, stratification variable, and cluster variable (primary sampling unit, represented by the survey-point identification number)

provided by the survey were incorporated to obtain population-representative estimates and design-based standard errors. Differences in current e-cigarette use according to participants’ characteristics were examined using complex-sample cross-tabulation analysis. Statistical significance was assessed using the second-order Rao–Scott adjusted chi-square test. Weighted percentages and unweighted frequencies were calculated.

Factors associated with current e-cigarette use were examined using complex-sample binary logistic regression analysis. Design-based standard errors were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs). Variables significant in the univariable analyses were considered for inclusion in the multivariable model. Education level was also included a priori as a theoretically relevant socioeconomic covariate, regardless of its statistical significance in the univariable analysis, based on previous Korean evidence [14].

Ethical considerations

CHSs were conducted with the approval of the Medical Research Ethics Review Committee of the Korea Disease Control and Prevention Agency. This study was a secondary analysis of publicly available anonymized data and was granted an Institutional Review Board (IRB) exemption (Kunsan National University; IRB approval No. 1040117-202607-HR-047-01). Consistent with the user-signed original data usage agreement, we requested and received raw data from which all personal identification numbers and personal information were deleted. Therefore, participant anonymity was strictly guaranteed as all individual data were handled using designated identification numbers only.

RESULTS

Among the 70,552 female workers, 1,108 participants were classified as current e-cigarette users and 69,444 as non-users. The weighted prevalence of current e-cigarette use was 2.5% (Table 1). Table 2 presents the differences in current e-cigarette use according to participants’ characteristics. Current e-cigarette use was significantly associated with age and marital status, but not with educational attainment. Younger participants were more likely to use e-cigarettes: among current e-cigarette users, 46.7%

Table 1. Current e-cigarette use of participants (N=70,552)

Current e-cigarettes use	N (weighted %)
Yes	1,108 (2.5)
No	69,444 (97.5)

Table 2. Comparison of current e-cigarette use by characteristics of participants (N=70,552)

Variables	Current e-cigarettes use, N (weighted %)		P-value
	Yes	No	
Demographic characteristic			
Age (yr)			
19–29	438 (45.7)	6,330 (15.9)	<0.001
30–39	318 (28.1)	8,409 (17.5)	
≥40	352 (26.2)	54,705 (66.6)	
Marital status			
Single	740 (69.3)	23,550 (36.7)	<0.001
Married	368 (30.7)	45,883 (63.3)	
Education			
High school or less	506 (41.1)	41,170 (43.5)	0.157
College or higher	602 (58.9)	28,246 (56.5)	
Health related characteristics			
Subjective health status			
Good	446 (40.6)	27,236 (45.8)	0.008
Moderate	546 (49.5)	32,320 (45.6)	
Poor	116 (9.8)	9,888 (8.6)	
Stress			
Yes	1,007 (91.4)	56,019 (84.4)	<0.001
No	101 (8.6)	13,425 (15.6)	
Depression			
Yes	208 (19.9)	5,341 (8.0)	<0.001
No	900 (80.1)	64,100 (92.0)	
Breakfast consumption (times/wk)			
<3	766 (70.2)	20,772 (39.3)	<0.001
≥3	342 (29.8)	48,672 (60.7)	
Current drinking			
Yes	833 (76.6)	29,514 (50.2)	<0.001
No	275 (23.4)	39,930 (49.8)	
Aware of smoke-free areas			
Yes	523 (49.5)	42,258 (60.7)	<0.001
No	585 (50.5)	27,186 (39.3)	

Values are presented as unweighted frequencies and weighted column percentages. *P*-values were calculated using the second-order Rao-Scott adjusted chi-square test.

were aged 19–29 years, 28.1% were aged 30–39 years, and 26.2% were aged 40 years or older ($P<0.001$). Single females accounted for 69.3% of current e-cigarette users, compared with 30.7% who were married ($P<0.001$).

Among the health-related characteristics, subjective health status was significantly associated with current e-cigarette use ($P=0.008$). Among current e-cigarette users, 40.6% rated their health as good, 49.5% as moderate, and 9.8% as poor. Stress was reported by 91.4% of current e-cigarette users, compared with 84.4% of non-users ($P<0.001$). Depressive symptoms were reported by 19.9% of current e-cigarette users and 8.0% of non-users ($P<0.001$). Breakfast consumption was also significantly associated with current e-cigarette use. Among current e-cigarette users, 70.2% reported eating breakfast fewer than <3 times/wk, whereas 29.8% reported eating breakfast three or

more times per week ($P<0.001$). Current drinking was reported by 76.6% of current e-cigarette users, compared with 50.2% of non-users ($P<0.001$). Awareness of smoke-free areas was lower among current e-cigarette users than among non-users: 49.5% of users were aware of smoke-free areas, compared with 60.7% of non-users ($P<0.001$).

Table 3 presents the results of the complex-sample logistic regression analysis examining factors associated with current e-cigarette use among female workers. The final model was statistically significant (Wald $F=101.680$, $P<0.001$) and yielded a Nagelkerke pseudo- R^2 of 0.172. After adjustment for the covariates, marital status, educational attainment, subjective health status, stress, depressive symptoms, breakfast consumption, current drinking, awareness of smoke-free areas, and age group were significantly associated with current e-cigarette use. Age was

Table 3. Logistic regression of factors influencing e-cigarette use (N=70,511)

Variables	OR (95% CI)	P-value
Demographic characteristic		
Age (yr), Ref. ≥40		
19–29	5.58 (4.42–7.03)	<0.001
30–39	4.28 (3.46–5.30)	<0.001
Marital status, Ref. Married		
Single	2.07 (1.73–2.48)	<0.001
Education, Ref. College or higher		
High school or less	2.62 (2.20–3.12)	<0.001
Health related characteristics		
Subjective health status, Ref. Good		
Moderate	1.57 (1.35–1.82)	<0.001
Poor	1.87 (1.44–2.45)	<0.001
Stress, Ref. No		
Yes	1.42 (1.12–1.78)	0.003
Depression, Ref. No		
Yes	2.26 (1.88–2.71)	<0.001
Breakfast consumption, Ref. ≥3		
<3	2.18 (1.85–2.56)	<0.001
Current drinking, Ref. No		
Yes	2.29 (1.94–2.71)	<0.001
Aware of smoke-free areas, Ref. No		
Yes	0.58 (0.49–0.65)	<0.001

The final multivariable complex-sample logistic regression model included 70,511 participants. This represents the initial analytic population of 70,552 participants after exclusion of 41 unique cases with missing values in one or more covariates included in the model. Values are presented as OR (95% CI). The final complex-sample logistic regression model was statistically significant (Wald $F=101.680$, $P<0.001$) and yielded a Nagelkerke pseudo- R^2 of 0.172. The model incorporated the sampling strata, clusters, and sampling weights. CI, confidence interval; OR, odds ratio; Ref., reference.

significantly associated with e-cigarette use. Compared with females aged 40 years or older, females aged 19–29 years (OR=5.58, 95% CI=4.42–7.03) and those aged 30–39 years (OR=4.28, 95% CI=3.46–5.30) had higher odds of e-cigarette use (overall $P<0.001$). Compared with married females, single females had higher odds of current e-cigarette use (OR=2.07, 95% CI = 1.73–2.48, $P<0.001$). Females with a high school education or less had higher odds of e-cigarette use than those with a college education or higher (OR=2.62, 95% CI=2.20–3.12, $P<0.001$). Compared with females who reported good subjective health, those reporting poor health (OR=1.87, 95% CI=1.44–2.45) or moderate health (OR=1.57, 95% CI=1.35–1.82) had higher odds of e-cigarette use; the overall effect of subjective health status was statistically significant ($P<0.001$). Females who experienced stress had higher odds of e-cigarette use than those who did not (OR=1.42, 95% CI=1.12–1.78, $P=0.003$). Participants who reported depressive symptoms also had higher odds of e-cigarette use (OR=2.26, 95% CI=1.88–2.71, $P<0.001$). Females who ate breakfast two times or fewer per week had higher odds of e-cigarette use than those who ate breakfast three or more times per week (OR=2.18, 95% CI=1.85–2.56, $P<0.001$). Current drinkers

had higher odds of e-cigarette use than non-drinkers (OR=2.29, 95% CI=1.94–2.71, $P<0.001$). Compared with females who were unaware of smoke-free areas, those who were aware had lower odds of current e-cigarette use (OR=0.58, 95% CI=0.49–0.65, $P<0.001$). Overall, current e-cigarette use was associated with younger age, single marital status, lower educational attainment, poorer subjective health, stress, depressive symptoms, infrequent breakfast consumption, and current alcohol use.

DISCUSSION

The present study investigated factors associated with current e-cigarette use among Korean female workers using data from the 2023 CHS. Younger age, marital status, educational attainment, subjective health status, psychological distress, breakfast frequency, current alcohol use, and awareness of smoke-free areas were significantly associated with e-cigarette use. Our findings both align with and meaningfully extend recent research on tobacco use among Korean females [13]. Whereas the previous study focused on females of childbearing age, the present study specifically examined economically active females

and identified population-specific sociodemographic, psychological, and health-related behavioral correlates of e-cigarette use among female workers.

Younger age and single marital status showed strong positive associations with e-cigarette use, consistent with prior evidence highlighting young adults' exposure to social media marketing and social support dynamics [15-20]. Notably, an important methodological finding emerged regarding educational attainment. While bivariate analysis indicated a higher proportion of e-cigarette users among college graduates, multivariate analysis revealed that lower educational attainment (high school or less) was independently associated with substantially higher odds of e-cigarette use. This reversal reflects a suppression effect caused by age and socio-behavioral covariates. In Korea, higher educational attainment is concentrated among younger demographics who also exhibit higher vaping rates. Once age and lifestyle factors were controlled for, lower educational attainment emerged as a true socioeconomic risk factor, aligning with literature on health literacy and resource inequalities [14].

Health status and psychological distress—including self-rated health, stress, and depression—were consistently associated with elevated odds of vaping [21,22]. Female workers facing occupational strain and gendered workplace pressures may utilize e-cigarettes as a coping mechanism. Similarly, health-risk behaviors such as breakfast skipping and current alcohol use were linked to e-cigarette use, underscoring behavioral clustering [22-24]. Conversely, awareness of smoke-free policies served as a protective factor, supporting the rigorous enforcement of workplace tobacco-free policies [1,25].

Study limitations include its cross-sectional design, reliance on self-reports susceptible to social desirability bias [2], and the lack of unmeasured workplace characteristics (e.g., job strain, working hours, shift work). Nevertheless, these findings highlight the need for comprehensive, gender-responsive, and workplace-based interventions targeting vulnerable female workers.

ORCID

Eungyeong KIM, <https://orcid.org/0000-0002-0419-5752>

AUTHOR CONTRIBUTIONS

Dr. Eungyeong KIM had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Author reviewed this manu-

script and agreed to individual contributions.

Conceptualization: EK. Writing—original draft: EK. Writing—review & editing: EK.

CONFLICTS OF INTEREST

No existing or potential conflict of interest relevant to this article was reported.

FUNDING

None.

DATA AVAILABILITY

The data presented in this study are available upon reasonable request from the corresponding author.

REFERENCES

1. World Health Organization. WHO report on the global tobacco epidemic 2021: addressing new and emerging products [Internet]. World Health Organization; 2021 Jul 27 [cited 2026 Jul 21]. Available from: <https://www.who.int/publications/i/item/9789240032095>
2. Park JE, Jeong WM, Choi YJ, Kim SY, Yeob KE, Park JH. Tobacco use in Korea: current epidemiology and public health issues. *J Korean Med Sci* 2024;39(45):e328.
3. Korea Disease Control and Prevention Agency. 2023 Korea National Health and Nutrition Examination Survey results released [Internet]. Korea Disease Control and Prevention Agency; 2024 Dec 23 [updated 2025 Jan 20; cited 2026 Jul 21]. Available from: https://www.kdca.go.kr/eng/4289/subview.do;jsessionid=B-5bqKc8ZVZGUm6AVwcMsBmNg27r7MOKm9WpWICwE.kdca_20?enc=Zm5jdDF8QEB8JTJGYmJzJTJGZW5nJTJGMT-g5JTJGMjA2MzAzJTJGYXJ0Y2xWaWV3LmRvJTNG
4. Glantz SA, Bareham DW. E-cigarettes: use, effects on smoking, risks, and policy implications. *Annu Rev Public Health* 2018;39:215-35.
5. Chun LF, Moazed F, Calfee CS, Matthay MA, Gotts JE. Pulmonary toxicity of e-cigarettes. *Am J Physiol Lung Cell Mol Physiol* 2017;313(2):L193-206.
6. Jeong W, Song MJ, Shin JH, Kim JH. Association between electronic cigarette use and risk of obstructive sleep apnea among Korean adults: a cross-sectional nationwide population-based

- study. *J Clin Med* 2025;14(11):3616.
7. Kim CY, Paek YJ, Seo HG, Cheong YS, Lee CM, Park SM, et al. Dual use of electronic and conventional cigarettes is associated with higher cardiovascular risk factors in Korean men. *Sci Rep* 2020;10(1):5612.
 8. Cho YS, Kim HR, Myong JP, Kim HW. Association between work conditions and smoking in South Korea. *Saf Health Work* 2013;4(4):197-200.
 9. Boo S, Oh H. Females's smoking: relationships among emotional labor, occupational stress, and health promotion. *Workplace Health Saf* 2019;67(7):361-70.
 10. Becker TD, Arnold MK, Ro V, Martin L, Rice TR. Systematic review of electronic cigarette use (vaping) and mental health comorbidity among adolescents and young adults. *Nicotine Tob Res* 2021;23(3):415-25.
 11. Jang BN, Kim HJ, Kim BR, Woo S, Lee WJ, Park EC. Effect of practicing health behaviors on unmet needs among patients with chronic diseases: a longitudinal study. *Int J Environ Res Public Health* 2021;18(15):7977.
 12. Sørensen K, Van den Broucke S, Fullam J, Doyle G, Pelikan J, Slonska Z, et al. Health literacy and public health: a systematic review and integration of definitions and models. *BMC Public Health* 2012;12:80.
 13. Kim E. Analysis of e-cigarettes related to health behaviors among females of childbearing age: focused on Korean Community Health Survey. *J Korean Matern Child Health* 2026;30(1):47-52.
 14. Kim JE, Lee JA, Cho HJ. Gender-based socioeconomic inequality of electronic cigarettes and heated tobacco products in Korea. *J Korean Soc Res Nicotine Tob* 2024;15(3):96-106.
 15. Kava CM, Hannon PA, Harris JR. Use of cigarettes and e-cigarettes and dual use among adult employees in the US workplace. *Prev Chronic Dis* 2020;17:E16.
 16. Chivers LL, Hand DJ, Priest JS, Higgins ST. E-cigarette use among females of reproductive age: impulsivity, cigarette smoking status, and other risk factors. *Prev Med* 2016;92:126-34.
 17. Pokhrel P, Fagan P, Herzog TA, Laestadius L, Buente W, Kawamoto CT, et al. Social media e-cigarette exposure and e-cigarette expectancies and use among young adults. *Addict Behav* 2018;78:51-8.
 18. Kim J, Lee S, Chun J. An international systematic review of prevalence, risk, and protective factors associated with young people's e-cigarette use. *Int J Environ Res Public Health* 2022;19(18):11570.
 19. Shafie-Khorassani F, Piper ME, Jorenby DE, Baker TB, Benowitz NL, Hayes-Birchler T, et al. Associations of demographics, dependence, and biomarkers with transitions in tobacco product use in a cohort of cigarette users and dual users of cigarettes and e-cigarettes. *Nicotine Tob Res* 2023;25(3):462-9.
 20. Krishnapillai A, Kee CC, Ariaratnam S, Jaffar A, Omar MA, Sanaudi RB, et al. Social support among older persons and its association with smoking: findings from the National Health and Morbidity Survey 2018. *Healthcare (Basel)* 2023;11(16):2249.
 21. Obisesan OH, Mirbolouk M, Osei AD, Orimoloye OA, Uddin SMI, Dzaye O, et al. Association between e-cigarette use and depression in the Behavioral Risk Factor Surveillance System, 2016-2017. *JAMA Netw Open* 2019;2(12):e1916800.
 22. Hefner KR, Sollazzo A, Mullaney S, Coker KL, Sofuoglu M. E-cigarettes, alcohol use, and mental health: use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addict Behav* 2019;91:12-20.
 23. Pengpid S, Peltzer K. Skipping breakfast and its association with health risk behaviour and mental health among university students in 28 countries. *Diabetes Metab Syndr Obes* 2020;13:2889-97.
 24. Kim H, Kim V. Smoking rate of electronic cigarettes and its related factors within the last one month. *J Converg Inf Technol* 2021;11(2):153-62.
 25. World Health Organization. Tobacco: e-cigarettes [Internet]. World Health Organization; 2024 Jan 19 [cited 2026 Jul 21]. Available from: <https://www.who.int/news-room/questions-and-answers/item/tobacco-e-cigarettes>

Instructions for Authors

Revised in September, 2026 (7th)
 Revised in January, 2024 (6th)
 Revised in January, 2016 (5th)
 Revised in June, 2011 (4th)
 Revised in June, 2009 (3rd)
 Revised in June, 2007 (2nd)
 Revised in March, 2003 (1st)
 Enacted in March, 2001

The Korean Journal of Health Promotion (KJHP) is an open access, multidisciplinary journal dedicated to publishing high-quality research in various areas of the medical, nursing, nutritional, physical educational, epidemiological, and public health sciences associated with health promotion and disease prevention.

The manuscript should be prepared according to the “ICMJE Recommendations for the Conduct, Reporting, and Publication of Scholarly Work in Medical Journals” (2023) (<https://www.icmje.org/recommendations/>). Matters unspecified in this document will follow the general principles of writing and editing of biomedical publication.

1. MANUSCRIPT SUBMISSION

All manuscripts must be submitted online via the online manuscript submission and review system for *KJHP* (<https://submit.e-kjhp.org/>)

Editor-in-Chief

Prof. Seung-Kwon MYUNG, MD, PhD
 Department of Family Medicine, National Cancer Center
 Department of Public Health & AI, National Cancer Center
 Graduate School of Cancer Science and Policy

Editorial Office

Department of Family Medicine, Asan Medical Center, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea

Tel: +82-2-3010-3820

Tel: +82-2-3010-3815

E-mail: kshdp@amc.seoul.kr

For manuscript submission, please visit <https://submit.e-kjhp.org/>

2. CATEGORIES OF ARTICLES

KJHP publishes original articles, review articles (narrative reviews and systematic reviews without meta-analyses), letters to the editor, letters in reply, editorials, and viewpoints.

*Summary of Article Types

Article Type	Description	Requirements
Original Article	Cross-sectional study Case-control study Cohort study Clinical trial Meta-analysis Qualitative research Survey research Other observational or original research	• ≤3,500 words • ≤10 tables and/or figures • Structured abstract, ≤300 words • Key Points: Question, Findings, and Meaning, ≤100 words • ≤50 references • Title Page including Key Points • Manuscript text: Title, Abstract, Keywords, Introduction, Methods, Results, Discussion, Acknowledgments, Author Contributions, References, Figure Legends, and Tables • Figures uploaded separately • Cover letter
Review Article	Narrative review (general review) Systematic review without meta-analysis	• ≤3,500 words • ≤10 tables and/or figures • Unstructured abstract for narrative review and structured abstract for systematic review, ≤300 word • Key Points: Question, Findings, and Meaning, ≤100 words • ≤50 references • Subtitle should be ‘A Narrative Review or A Systematic Review’ • Title Page including Key Points • Manuscript text: Title, Abstract, Keywords, Introduction, Methods, Results, Discussion, Acknowledgments, Author Contributions, References, Figure Legends, and Tables • Figures uploaded separately • Cover letter

Letter to the Editor	Letters discussing a recent article in this journal should be submitted within 4 weeks of the article's publication in print.	• ≤1,000 words • ≤5 references • ≤3 authors • No abstract required
Letter in Reply	Replies by authors of original articles to letters from readers.	• ≤1,000 words • ≤5 references • ≤3 authors • No abstract required
Editorial	An opinion or a view of a member of the editorial board or any senior or reputed faculty written in a journal	• ≤1,000 words • 1 author • No abstract required
Viewpoint	A short opinion which focuses on some of the key topics, issues, or developments in health promotion and disease prevention	• ≤1,500 words • ≤10 references • ≤3 authors • Unstructured abstract, ≤150 words

3. MANUSCRIPT PREPARATION AND SUBMISSION REQUIREMENTS

1) Original Article and Review Article

Manuscript Style

Manuscripts should be prepared in accordance with the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals (<https://icmje.org/recommendations>) and written in proper and clear English.

Manuscript Components

The authors should prepare at least 3 files such as a cover letter, title page (with author details), manuscript text (no author identifiers), and as appropriate, figures. Start each of these sections on a new page, numbered consecutively. Tables should be included in the manuscript text, and figures should be uploaded as separate files (individual or combined figure files) and not included in the manuscript text. Also, a copyright transfer form should be signed by a corresponding author on behalf of all authors and submitted (a link for downloading the form should be inserted here).

Manuscript File Formats

For submission and review, please submit the manuscript as a Word document (e.g., Microsoft Office Word). Do not submit your manuscript in PDF format. For submission of drawings, photos, graphs, or combined figures, PPT and PDF formats are acceptable.

Use 12-point font size, double-space text, and leave both margins justified.

Cover Letter (≤200 words)

Prepare a cover letter. This is a great opportunity to highlight to the journal editor what makes your research new and important. The cover letter should explain why your work is perfect for the *KJHP* and why it will be of interest to our readers. The cover letter should have a maximum of 200 words and include complete contact information for the corresponding author (affiliation, postal/mail address, email address, and telephone number) and whether the authors have published, posted, or submitted any related papers from the same study.

Title Page (≤300 words)

The title page should include an article title; running head; type of study design; the full names, academic degrees, and affiliations of all authors (if an author's affiliation has changed since the work was done, the new affiliation also should be listed); name and complete contact information for corresponding author; word count of the abstract and manuscript text (not including title, abstract, acknowledgment, references, tables, and figure legends); total number of tables; total number of figures; number of references; funding sources; declaration of conflict of interests; and key points.

Provide ORCID IDs for all authors. Titles should be concise, specific, and informative. Limit the length of titles to 30 words. A running head or running title is a short version of the article title, which should consist of no more than 10 words.

The key points is a short structured summary of the findings of your manuscript (required only for research and review manuscripts), following 3 key points: Question, Findings, and Meaning. Limit to 100 words or less.

<Example>

Key Points

Question: Is intermittent high-dose vitamin D supplementation effective in the prevention of falls and fractures?

Findings: In this meta-analysis of 15 randomized controlled trials, intermittent high-dose vitamin D supplementation showed no beneficial effect in the prevention of falls and fractures and even showed a harmful effect in the high-quality trials.

Meaning: Our findings support that intermittent high-dose vitamin D supplementation for the prevention of falls and fractures should be discouraged.

Manuscript Text

A manuscript text should be prepared in the following sequence: title, abstract, keywords, introduction, methods, results, discussion, acknowledgments, author contributions, references, figure legends, and tables. The full text containing introduction, methods, results, and discussion should not exceed 3500 words.

Title (≤30 words)

An article title should be inserted at the top of the first page of the manuscript text file.

Abstract (≤300 words) and Keywords

An abstract should briefly summarize the content of the manuscript in a structured format for a systematic review and an unstructured format for a narrative review and should not exceed 300 words. The structured abstract should be structured as follows: Background, Methods, Results, and Conclusions. Three to six keywords should be listed after the abstract.

Introduction (≤500 words)

Describe a brief background and purpose of the study and elaborate on its significance. Summarize the rationale and include only strictly pertinent references.

Methods (≤1,000 words)

Identify the methods. Describe study participants, controls, or laboratory animals clearly and identify procedures in sufficient details to allow other researchers to reproduce the results. Identify the apparatus or reagents used by giving the product's name, followed by the name of the product company in parentheses. Give references to established methods, including statistical methods. Provide references and brief descriptions for methods that have been published but are not well known or substantially modified, and give reasons for using them and evaluate their limitations.

Describe statistical methods with enough details to verify the reported results. Whenever possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Avoid relying solely on statistical hypothesis testing, such as the use of *P*-values, which fails to convey important quantitative information. When the results of the data in the text are given, provide details specifically in terms of average, proportion, or correlation coefficient to describe the difference between study groups or the relevant size and direction of variables. Specify statistical

software used for statistical analysis.

Results (≤1,000 words)

Present the findings and results in logical sequence in the text, tables, and figures. Do not repeat in the text all data in the tables or figures, but describe important points and trends.

Discussion (≤1,000 words)

Emphasize the new and important aspects of the study and the conclusions that follow from them. Do not repeat in detail data or other materials given in the Introduction or the Results section. Include the implications of the findings and their limitations, including implications for future research. Link the conclusions with the purpose of the study by discussing and comparing the relevant results of other research data. Avoid unqualified statements and conclusions not completely supported by the data. Propose new hypotheses when warranted and recommendations, when appropriate, may be included.

Acknowledgments

If necessary, persons who have contributed to the article but whose contributions do not meet authorship standards may be appreciated through acknowledgment section. Clearly state their contributing role for acknowledgement. For example, data collection, financial support, statistical analysis, analysis of experiment, and so forth. Authors should notify that their names will be in the Acknowledgement and are responsible for obtaining permission from persons acknowledged.

Author Contributions

What authors have done for the study should be described in this section. To qualify for authorship, all contributors must meet at least one of the seven core contributions by CRediT (conceptualization, methodology, software, validation, formal analysis, investigation, data curation), as well as at least one of the writing contributions (original draft preparation, review, and editing).

The submitting author is responsible for completing this information at submission, and it is expected that all authors will have reviewed, discussed, and agreed to their individual contributions ahead of this time.

<Example>

Dr. MYUNG had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy

of the data analysis. All authors reviewed this manuscript and agreed to individual contributions.

Conceptualization: SKM.

Data curation: SWO and YJC.

Formal analysis: YJC.

Methodology: SKM, SWO, and YJC.

Software: SKM and YJC.

Writing - original draft: YJC.

Writing - review & editing: SKM, SWO, and YJC.

References

Authors are responsible for the accuracy and completeness of their references and for correct text citation. In the text, references should be cited with Arabic numerals in brackets, numbered in the order cited. In the references section, the references should be numbered and listed in order of appearance in the text. If there is more than one reference cited coincidentally, then a comma separates the numbers and only the last number is closed with a right bracket. If a consecutive number of references is cited together, then a hyphen ‘-’ should be used between the first and the last number.

List all authors and/or editors up to 6; if more than 6, list the first 6 followed by “et al.” Journal references should include the issue number in parentheses after the volume number. Reference styles are as follows:

Journal articles

Name(s) of author(s). Title of article. Abbreviated journal name. Year of publication; Volume number (Issue number): Page numbers.

<Example> Myung SK, Oh SW, Choi YJ. How to use the KJHP’s online manuscript submission system. Korean J Helath Promot 2024;24(1):123-7.

Books

Name(s) of author(s). Title of publication: subtitle. Edition. Publisher; Year of publication. p. Page numbers.

Name(s) of the chapter’s author(s). Title of chapter. In: Name(s) of the editor(s). Title of publication. Edition. Publisher; Year of publication. p. Page numbers.

Conference proceedings

Name(s) of author(s). Title of conference proceedings. Title of conference; Date of conference; Place of conference. Publisher; Year of publication.

Dissertations

Name of author. Title of thesis [dissertation]. Name of university; Year when degree was given. Language of dissertation.

Journal articles in electronic media

Name(s) of author(s). Title of article. Abbreviated title of journal [Internet]. Year of publication; Volume number (Issue number): Page numbers. Name of source URL:

Website or online sources

Name(s) of author(s). Title of web page [Internet]. Name of publisher; Year of publication [Date of citation]. Available from: available URL

Figure Titles and Legends (Captions)

After references, include a title for each figure. The figure title should be a brief descriptive phrase, preferably no longer than 10 to 15 words. A figure legend (caption) can be used for a brief explanation of the figure or markers if needed and expansion of abbreviations.

Tables

All tables should be inserted after figure legends in the manuscript text. Restrict tables and figures to those needed to explain and support the argument of the article and to report all outcomes identified in the Methods section. Number each table and figure and provide a descriptive title for each. Every table and figure should have an in-text citation. Verify that data are consistently reported across text, tables, figures, and supplementary material. The number of tables and /or figures should not exceed 10.

Within a table, if an abbreviation is used or a description may be necessary, then list them under annotation below. Use the alphabet in the order of a, b, c by superscript on the right side of the part that needs explanation and the annotation should be recorded according to the symbols listed below the table. For each annotation marked, the first letter of the first word should be capitalized. The *P* of the *P*-value should also be capitalized. The title of the table should be on the top placed at the right end of the table. The title of the figure should also be on the top placed at the right end of the figure. The numbering of the table or figure should be in the order of entry in the main text, and Arabic numeral should be used after a space of the word ‘Table (Figure)’ followed by a period. The first letter of the first word should be capitalized. In making a table, the average and stan-

dard deviation, the number of participants and other figures should be given and on the annotated part of the table, the applied statistical method should be noted. For ratio, the number of responders and the ratio, and for correlation coefficient, the value of correlation coefficient should be given, respectively.

Figures

Number all figures (graphs, charts, photographs, and illustrations) in the order of their citation in the text. When illustrating a figure, use a bar or a line graph for average or proportion, and list measures using standard deviation or standard error and must show their *P*-values. Identify the applied statistical methods at the footnote of each figure. Primary outcome data should not be presented in figures alone. Exact values with measure of variability should be reported in the text or table as well as in the abstract. All symbols, indicators (including error bars), line styles, colors, and abbreviations should be defined in a legend. Each axis on a statistical graph must have a label and units of measure should be labeled. Error bars should be included in both directions, unless only 1-sided variability was calculated.

Acceptable file formats are .jpg, .tif, .pdf, .ppt, .psd, and .eps. Required minimum resolution for publication is 300 ppi.

Abbreviations

Overindulgence with the use of abbreviations is forbidden, and the use of abbreviations must be minimized. Only standardized abbreviations may be used and abbreviations should not be used in titles or abstracts. With the exception of measurement units, abbreviation should be specified when first introduced in the text and then may be used independently.

Units of Measurement

Laboratory values are expressed using conventional units of measure, with relevant Systeme International (SI) conversion factors expressed secondarily (in parentheses) only at first mention. Figures and tables should use conventional units, with conversion factors given in legends or footnotes. The metric system is preferred for the expression of length, area, mass, and volume.

Names of Drugs, Devices, and Other Products

Generic names should be used. When proprietary brands are used in research, include the brand name and the name of the manufacturer in parentheses after the first mention of the generic name in the Methods section.

Generic Names, Numbers, and Measurement Units

Personal, geographical and generic names must be written in original language, if possible, and numbers must be written in Arabic numerals. The measurement units such as length, height, mass and volume should be indicated in the metric system (meter, kilogram, liter etc). Temperature must be indicated in centigrade and blood pressure in mmHg. Units for blood and clinical laboratory test measurements should be expressed in the ordinary scale or by International Units (SI). A space is required between a measured value and its unit.

Supplementary Materials

Supplementary materials for online-only publication can be submitted, when there is insufficient space to include the materials in the manuscript text or figures. Because supplementary materials are not edited or formatted after publication, authors are responsible for the accuracy and presentation of these materials.

Reporting Sex/Gender

The term sex (male, female) should be used when reporting biological factors and gender (man, woman) should be used when reporting gender identity or psychosocial/cultural factors. The methods used to obtain information on sex, gender, or both (e.g., self-reported, investigator observed or classified, or laboratory test) should be explained in the Methods section. If only one sex is reported, or included in the study, the reason the other sex is not reported or included should be explained in the methods section, except for studies of diseases/disorders that only affect males (e.g., prostate disease) or females (e.g., ovarian disease). The sex distribution of study participants or samples should be reported in the results section, including for studies of humans, tissues, cells, or animals. Study results should disaggregate and report all outcome data by sex.

2) Letters to the Editor, Letters in Reply, Editorials, and Viewpoints

For preparation of Letters to the Editor, Letters in Reply, Editorials, and Viewpoints, refer to 'Summary of Article Types' in the categories of articles section.

4. REPORTING GUIDELINES FOR SPECIFIC STUDY DESIGNS

Authors should be aware of the information that must be included in the contents of the research according to the study

design and must reflect them in their articles. Authors should refer to STROBE (<http://www.strobe-statement.org>) for observational studies, CONSORT (<http://www.consort-statement.org>) for randomized controlled trials, STARD (<http://www.stard-statement.org>) for studies of diagnostic accuracy, and PRISMA (<https://www.equator-network.org/reporting-guidelines/prisma/>) and MOOSE ([https://www.equator-network.org/reporting-guidelines/meta-analysis-of-observational-studies-in-epidemiology-moose-group/](https://www.equator-network.org/reporting-guidelines/meta-analysis-of-observational-studies-in-epidemiology-a-proposal-for-reporting-meta-analysis-of-observational-studies-in-epidemiology-moose-group/)) for systematic reviews and meta-analyses.

5. MANUSCRIPT REVIEW AND PUBLICATION

Upon submission of a manuscript, the Editorial Committee will review the article whether its contents meet the objectives of the Journal, and the article can be rejected at this initial review process. The Editorial Committee will entrust two or more experts with review of articles and will decide their acceptance for publication with the help of experts' recommendations. Based on comments from reviewers and editors, authors may be asked to revise their manuscripts. Authors are required to submit a revised manuscript and a letter of explanation regarding how they have dealt with all comments and questions raised by reviewers and editors through the electronic submission system. The Editorial Committee or the editor-in-chief may entrust an statistical expert with statistical review of articles at the final stage of review, and ask authors to revise their manuscripts, if necessary.

The acceptance for publication is decided by the Editorial Committee after its thorough review process, and the editor-in-chief will deliver an official approval of acceptance for publication.

This journal operates a double-anonymized peer-review process, meaning that the identities of the authors are concealed from the reviewers, and the identities of the reviewers are kept anonymous from the authors. Authors must prepare their manuscripts and supplementary files to ensure complete anonymity.

To ensure proper anonymization, please prepare your submission according to the following guidelines:

- **Separate Title Page:** Submit a separate title page file containing the full title, all author names, affiliations, and the corresponding author's contact details (email, phone, address). This file will not be sent to reviewers.
- **Anonymized Main Text:** Remove all author names, initials, institutional affiliations, and identifying acknowledgments

from the main manuscript file, running headers, and figures.

- **Self-Citations:** Refer to your own previous work in the third person (e.g., write "previous work has shown [Anonymous, 2020]" instead of "as we previously showed"). Do not delete essential self-references, but format them anonymously.
- **Funding and Acknowledgments:** Exclude funding sources, grant numbers, and acknowledgments from the anonymized manuscript text. These can be included in the title page or disclosure forms.
- **File Properties:** Clear any identifying metadata or author names from your electronic file properties and file names before uploading.

6. COPYRIGHT

Once publication of the manuscript has been decided, the copyright will be deferred to the Korean Society for Health Promotion and Disease Prevention, and the copyright of the manuscript published will belong to the Society. The Society is entitled to publish, distribute and print a manuscript in the journal or other media. As the time of submission, a corresponding author, on behalf of all authors, must sign and submit the 'copyright transfer agreement form', which must be downloaded from the homepage, to confirm that its copyright is assigned.

7. ETHICAL REGULATIONS

Review and handling procedures related to all research ethics including ethics regulations and plagiarism, duplicate publication, and research misconduct will be followed according to the 'Good Publication Practice Guidelines for Medical Journals (<http://kamje.or.kr/>)' stipulated by the Korean Association of Medical Journal Editors (KAMJE).

1) Ethical Review and Informed Consent

If the research involves human participants, it must comply with the ethical standards of the Declaration of Helsinki (adopted in 1964; amended in 2008; <https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/>) and in principle must undergo scrutiny of an independent Institutional Review Board (IRB) or Research Ethics Committee (REC) which reviews the ethical issues of the human experiment. However, in clinical studies, the approval of the IRB or ERC and participant's consent must be received and specified in the text.

Animal experiments also should be reviewed by an appropriate committee (IACUC) for the care and use of animals. Also, studies with pathogens requiring a high degree of biosafety should pass review of a relevant committee (IBC). The approval should be described in the Methods section.

2) Privacy and Confidentiality

Every author must protect privacy and confidentiality of study participants. The personal information regarding the identity of a study participant must not be disclosed in any form: article, photo or pedigree. However, if a study participant's personal information is indispensable as scientific information, it must be explained to the study participant or his/her legal guardian, written informed consent should be obtained from him/her before publication, and his/her approval must be specified in a published article. At the time of explanation, a manuscript to be published, including photos, must be offered to a study participant and be approved by him/her. Description materials including photographs should not disclose study participant's name, english initials, and hospital identification number.

3) Redundant Publication/Duplicate Submission

An article that has been already reported in another journal or is being reviewed by another journal, and an article that has a redundant material previously published in the journal will be rejected. If the article contains similar work that has already been reported in another publication or has been published in the journal, the author should include copies of such material along with the submitted article. The Editorial Committee will decide on the matter of secondary publication of the submitted article and then consider for its acceptance. Also, the author can not submit a published article to another journal without authorization. Only under the conditions for secondary publication stipulated in the 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals' this may be allowed.

4) Authorship and Contributorship

Every author must meet the authorship standards set forth in the 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals'. He/she has a duty of verifying that his/her article has not yet been published and is not the same as any existing one. All persons designated as authors must fulfill all three conditions that they had contributed to 1) conception and design, acquisition of data, or analysis and interpretation of data, 2) drafting the article or revising it critically for important

intellectual content, and 3) final approval of the version to be published. All contributors participating in the research not meeting the authorship standards must be listed in 'Acknowledgments' section after receiving their permission. After a manuscript has been submitted, no author could not be added.

5) Conflicts of Interest and Financial Disclosures

Each author has a duty to disclose direct or indirect conflicts of interest in the subject matter discussed in the submitted article. All authors must reveal all possible conflicts of interest that related to research such as consultation fees and stocks when submitting their article and should provide all of their personal signatures to verify that they have revealed so. A financial grant or support received for research purposes should be disclosed at the bottom of the title page, and all conflicts of interest such as consulting fees and stocks associated with study should also be disclosed at the bottom of the title page or in acknowledgment section. The corresponding author is required to confirm whether his/her or his/her co-authors have any conflict of interest to declare, and to provide appropriate details to the Editorial Committee.

8. RESUBMISSION

The resubmission period for a manuscript sent to its author for revision must be three months, and if three months are exceeded, the manuscript must be judged again as a new manuscript.

9. PAGE PROOFS

Page proofs will be sent to corresponding authors by the Editorial Committee. Authors must send them back within 48 hours after reading them carefully and revising them if necessary. The revision of page proofs must be limited to the errors of typesetting, and it is prohibited to change or to add new contents to the article. Authors are responsible for the contents of page proofs.

10. ARTICLE PROCESSING CHARGE

No review fees are charged for all the submitted articles. Article processing charges are required for publication in the *KJHP*. Publication fees for all the accepted original or review articles are 300,000 Korean Won (250 US dollars). Additionally, if the article exceeds 6 pages of the journal, additional fees (50,000 Korean Won or 40 US dollars per extra page) will be charged.

11. CORRECTIONS

If necessary, requests to publish corrections should be sent to

the Editorial Committee within one month of journal publication. Corrections are reviewed by editors and authors and published in the next issue of the journal.

Copyright Transfer Agreement

Manuscript Title: _____

Authors: _____

On behalf of all authors of the manuscript entitled as above, I, as a corresponding author, certify that this article is an original work and that none of the material in the manuscript has been published previously or will be published. The authors warrant that they have obtained permission from the copyright holder to reproduce any materials and media including printed and electronic forms not owned by the authors, and that they have acknowledged the source.

Also, all the authors of this manuscript declare that there is no commercial association (e.g., financial interest, stock ownership, consultancy, patent and licensing agreement, etc.) that might pose a conflict of interest in relation to the submitted manuscript.

On behalf of all the authors, I hereby transfer, convey, and assign all copyrights in the Article to the *Korean Journal of Health Promotion (KJHP)*. Also, the copyright to the Contribution identified above is transferred to the *KJHP*. The copyright transfer covers the right to print, publish, distribute, and sell throughout the world the said Contribution and parts thereof, including all revisions or versions and future editions, in all forms and media expression – such as in its electronic form (offline, online) – now known or developed in the future, as well as to translate, print, publish, distribute, and sell the Contribution in any foreign languages and throughout the world.

Name of Corresponding Author: _____

Signature of Corresponding Author on behalf of All Authors: _____

Date: ____/____/____

Research Ethics Committee Regulations

Enacted April 22, 2026

Article 1 (Aims): These regulations provide rules for the matters of composition and operation of the Ethics Committee (referred to as “Committee”) of the Korean Journal of Health Promotion (referred to as ‘KJHP’), an official journal of the Korean Society for Health Promotion and Disease Prevention.

Article 2 (Composition):

1. The chairperson of the Committee is the Director of Publication from the Korean Society for Health Promotion and Disease Prevention (Editor-in-Chief of the KJHP).
2. The Committee consists of within 10 members including two directors of Korean Society for Health Promotion and Disease Prevention (Director of General Affairs and Director of Academic Affairs) and four associate (section) editors and an Ethics editor of the editorial committee.

Article 3 (Term): The term of the chairperson and members is three years from the appointment date and may be reappointed.

Article 4 (Mission): The Committee is responsible for the following matters:

1. Matters concerning research ethics and publication ethics of articles submitted or published in the KJHP.
2. Research activities to enhance ethical awareness in academic journals.
3. Consultation on the research ethics and publication ethics of the Korean Society for Health Promotion and Disease Prevention or member associations.
4. Other matters deemed necessary by the chairperson or two or more members.

Article 5 (Meeting): The committee meetings will be convened when the chairperson deems their necessity.

Article 6 (Decision): The committee meetings require the attendance of a majority of the incumbent members. Decisions is made with the approval of a majority of the members present, and rejected if there is a tie in votes.

Article 7 (Supplementary Provision): Matters not discussed in these regulations shall be proposed by the Committee and determined by the Board of Directors of the Korean Society for Health Promotion and Disease Prevention.

ADDITIONAL CLAUSE

Article 1 (Enforcement Date): This regulation shall be enforced on the date of approval by the Board of Directors of the Korean Society for Health Promotion and Disease Prevention.