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Association between health-related behaviors and obstructive sleep apnea among Korean adults

Yoongi Chung & Ji-Su Kim✉

We aimed to investigate the association between health-related behaviors and obstructive sleep apnea (OSA) among Korean adults. A cross-sectional design using national open data was employed. Data from 8,096 adults aged 40 years and above who participated in the Korea National Health and Nutrition Examination Survey between 2019 and 2021 were analyzed. The participants' OSA risk level was assessed using the STOP-Bang questionnaire. A logistic regression analysis was performed to investigate the association between health-related behaviors and high risk for OSA. The association between health-related behaviors and OSA risk remained significant for former smokers (OR = 1.643) and high-risk drinking (OR = 1.365), after adjusting for variables that showed significant differences in general and metabolic characteristics. Implementing lifestyle modifications is crucial for mitigating the health and societal impact of OSA. Understanding and addressing modifiable risk factors, including high-risk drinking and smoking, should be prioritized in nursing intervention. Nursing interventions are critical for preventing and managing OSA among Korean adults. Prioritizing high-risk behaviors through cessation programs and education is essential. Vulnerability of individuals living alone must be addressed through community outreach and support services. Emphasizing routine screenings for pre-hypertension and pre-diabetes, promoting balanced nutrition, and encouraging physical activity are crucial.

Keywords Obstructive sleep apnea, Health-related behaviors, Smoking, High-risk drinking, STOP-Bang questionnaire, Body mass index

Obstructive sleep apnea (OSA) is a common sleep-related breathing disorder manifested by repeated instances of partial or complete closure of the upper airway[1] leading to decreased airflow, disruptions in gas exchange and frequent sleep fragmentation[2]. With the worldwide increase in obesity, the prevalence and impact of OSA is growing steadily[3]. Benjafield et al.[4] estimated that approximately 1 billion individuals aged 30–69 worldwide have been diagnosed with OSA, with 425 million among them experiencing moderate to severe OSA requiring treatment. Untreated OSA has the potential to decrease quality of life and affect multiple areas of life[5], leading to depression[5], cognitive impairment[6], and cardiometabolic diseases(e.g., hypertension, diabetes, and cardiovascular diseases)[7]. Besides the negative health impact, the substantial economic cost burden of untreated OSA exceeds the amount incurred for diagnosing and treating OSA, necessitating timely diagnosis and management.

Polysomnography (PSG) is the standard diagnostic tool for OSA[8], where an apnea–hypopnea index (AHI) of 5 or more per hour of sleep indicates OSA and 15 or more indicates moderate OSA, and 30 or more indicates severe OSA[9]. However, PSG requires medical personnel and is costly and time-consuming, often leading to delays in OSA diagnosis[8]. Therefore, supplemental screening tools, such as the STOP-Bang questionnaire[10], are used to screen OSA risk at lower costs and involving less time. The STOP-Bang questionnaire is a convenient screening instrument in preoperative settings, yet it is applicable to the general population[11]. Its widespread utilization is attributed to its high precision in diagnosis, user-friendly nature, and explicit criteria for assessing risk levels[12].

Previous studies analyzing the prevalence of risk factors for OSA have identified age[13], male gender[14] and obesity[15], waist circumference[16], high triglyceride levels[16]. Other lifestyle factors such as smoking[17], alcohol consumption[18], diet[19], and physical activity[20] also relate to severe OSA. Health-related behaviors encompass a wide range of actions and habits related to restoring, maintaining, and improving health[21], including self-directed health behaviors such as diet, exercise, smoking cessation, and moderate consuming alcohol[22]. Identifying health-related behaviors associated with OSA is crucial, as it not only enables the application of lifestyle change interventions in OSA management but also facilitates their utilization for early prevention[23].

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In this study, we examined the association between health-related behaviors and the risk for OSA in the Korean adult population using, for the first time, national-level data from the Korea National Health and Nutrition Examination Survey (KNHANES) conducted in 2019–2021. We used participants' STOP-Bang questionnaire scores to identify the prevalence of OSA risk and differences in OSA risk based on general and metabolic characteristics and health-related behaviors to enhance our understanding of the current OSA risk status and gain insights into the establishment of potential public initiatives for OSA management in Korea.

Methods

Study population

Raw data of 20,714 respondents in the 2019–2021 KNHANES were reviewed. To ensure that each year of the three-year study period functions as an independent, nationally representative probability sample, a rolling-sampling survey method was implemented. This study included the population (aged 40 and above) surveyed for the items measuring OSA risk. Participants totaling 8096 satisfied our selection criteria after the sequential exclusion of those aged below 40 years (7650 participants) and those missing the STOP-Bang questionnaire (1810) and covariates (3,158) data (Fig. 1).

Obstructive sleep apnea

The STOP-BANG questionnaire, developed by Chung et al.[10], was used to assess the risk for OSA. It comprises four binary questions (STOP: snoring, tiredness, observed apnea, and high blood pressure) and four demographic questions (Bang: Body Mass Index (BMI) ≥ 30 kg/m^2, age ≥ 50, neck circumference ≥ 40 cm, and male). Each question answered with "yes" in the STOP questions or meeting the criteria in the Bang questions is awarded 1 point. Scores range from 0–8, and higher scores indicate a greater risk of severe OSA. Based on the scoring criteria, we categorized scores of 0–2 as low risk, 3–4 as intermediate risk, and 5–8 as high risk for OSA[24]. As the STOP-Bang score of ≥ 5 demonstrated a sensitivity of 80.0% and specificity of 76.9% in identifying severe OSA[25], we used the cutoff STOP-Bang score of ≥ 5 while investigating the association between high-risk OSA and health-related behaviors.

General characteristics of participants

The general characteristics of participants including age, sex, number of household members, living area, educational status, economic activity, and family income were examined.

Metabolic characteristics of participants

Metabolic characteristics that could have a potential impact on OSA included BMI (body mass index), waist circumference, hypertension, diabetes, and dyslipidemia. According to the World Health Organization Asia–Pacific region standards, BMI is classified as follows: normal (< 23 kg/m^2), overweight (23–25 kg/m^2), and obese (≥ 25 kg/

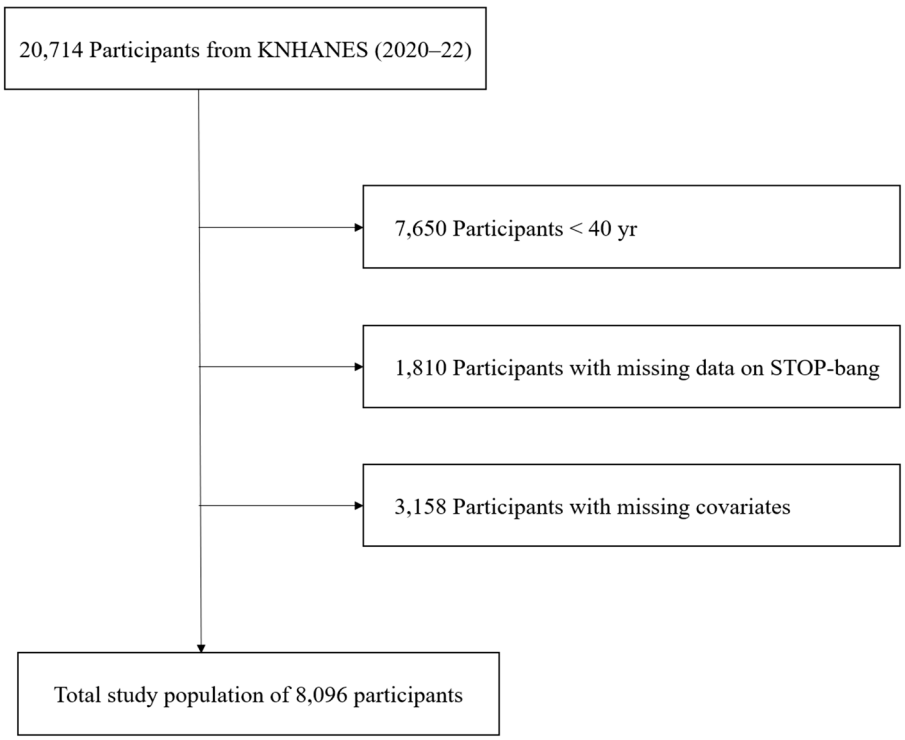

Fig. 1. Study population.

m^2)[26]. Waist circumference is categorized into cases of ≥ 90 cm in men and ≥ 85 cm in women[27]. Hypertension is categorized into three groups: normal, pre-hypertension, and hypertension. Diabetes is classified based on measurements of blood glucose levels taken after an 8-h fast, as diabetes, prediabetes, and normal. Dyslipidemia is classified as "yes" if any of the following occur: LDL ≥ 160 mg/dL, HDL < 40 mg/dL, total cholesterol ≥ 240 mg/dL, and triglycerides ≥ 200 mg/dL[28].

Health-related behaviors

In this study, health-related behaviors were assessed using variables related to smoking, drinking, physical activity, diet, and sleep. Smoking-related behaviors included smoking status and exposure to secondhand smoke either at home or workplace. The study respondents' smoking status was divided into three groups: "never," "former," and "current." Individuals who had smoked fewer than five packs of cigarettes during their lifetime were classified as "never"; those who had smoked more than five packs of cigarettes during their lifetime but were not currently smoking were categorized as "former"; individuals who had smoked more than five packs of cigarettes during their lifetime and were still smoking were considered as "current." Regarding drinking practices, monthly drinking was defined as alcohol consumption if the respondent had consumed at least once a month in the past year. High-risk drinking was defined as consuming an average of more than seven (five) drinks per occasion for men (women) and drinking alcohol on two or more occasions per week. We examined aerobic physical activity and sedentary time for physical activity. Aerobic physical activity was classified as "yes" for individuals who engaged in moderate-intensity physical activity for at least 2 h and 30 min per week, high-intensity physical activity for at least 1 h and 15 min per week, or a combination of moderate and high-intensity activities (i.e., 1 min of high-intensity activity is equivalent to 2 min of moderate-intensity activity) totaling the equivalent time for each activity. Sedentary time was defined as time spent sitting or lying down during a typical day[29]. Based on research findings suggesting that sedentary time exceeding 7 h may independently relate to all-cause mortality[30,31], we set the cutoff for sedentary time at 7 h. Frequency of eating out, breakfast skipping, and use of nutrition labeling were included in the diet category. We classified frequency of eating out based on a previous study[32] that focused on investigating the association between frequency of eating out and BMI as follows: rarely (< 1 time/month), sometimes (1–3 times/month), 1–2 times/week, and ≥ 3 times/week. We included breakfast skipping as a variable because there is evidence that breakfast skipping is associated with obesity[33]. Breakfast skipping was categorized based on frequency as follows: never have breakfast, eat 1–2 times/week, eat 3–4 times/week, eat 5–7 times/week. Use of nutrition labeling was also included, hypothesizing that people with obesity could be less inclined to use nutrition labels, as demonstrated by a prior study[34]. Sleep hours were categorized as < 6 h, 6–8 h, and > 8 h for both weekdays and weekends. Considering previous studies[35], we deemed those sleeping < 6 h (> 8 h) as short (long) sleepers. Catch-up sleep was determined by subtracting weekday sleep duration from weekend sleep duration. It was categorized as follows: no catch-up sleep, < 1 h, 1–2 h, and > 2 h.

Data analysis

The study data were analyzed using SPSS/Win 28.0. Differences in STOP-Bang scores based on general characteristics, metabolic characteristics, and health-related behavioral variables are expressed as percentages (%) and standard errors using the chi-square test. To investigate the association between health-related behaviors and individuals at high risk for OSA, a logistic regression analysis was performed by adjusting for general and metabolic characteristics that showed differences according to the STOP-Bang score as covariates.

Results

A total of 8,096 participants were categorized as low-risk, intermediate-risk, and high-risk groups based on their STOP-Bang scores, and the distribution of each risk group was examined (Fig. 2). The low-risk group included 5,024 individuals, accounting for 62.6% of the total; the intermediate-risk group comprised 2,601 individuals, representing 30.9%; the high-risk group consisted of 471 individuals, accounting for 6.6%.

Table 1 shows the risks for OSA according to participants' general characteristics. Significant differences in the risk for OSA were observed for all variables: age ($p < 0.001$), gender ($p < 0.001$), number of household members ($p = 0.015$), living area ($p < 0.001$), educational status ($p < 0.001$), economic activity ($p < 0.001$), and family income ($p < 0.001$). Compared with the actual proportion of the surveyed population, the group that exhibited a higher proportion in the high-risk group comprised those aged 50–59 years, 60–69 years, men, living in households with two or more members, residing in rural areas, an educational status of middle to high school, currently employed, and family income categorized as "middle" and "high."

Table 2 shows the risk for OSA according to participants' metabolic characteristics. Significant differences in OSA risk were observed for all variables ($p < 0.001$). When the original proportions are considered within each category variable's sample, variables that exhibited higher proportions in the OSA high-risk group compared with the actual proportions are as follows: BMI ≥ 25 kg/m^2, waist circumference ≥ 90 cm (men), ≥ 85 cm (women), pre-hypertension, hypertension, prediabetes, diabetes and, "yes" response to dyslipidemia.

Table 3 summarizes the risk for OSA based on participants' health-related behaviors. Among the health-related behavior variables, significant differences in the risk for OSA were observed for smoking status ($p < 0.001$), monthly drinking ($p < 0.001$), high-risk drinking ($p < 0.001$), sedentary time ($p = 0.002$), frequency of eating out ($p < 0.001$), breakfast skipping ($p < 0.001$), use of nutrition labeling ($p < 0.001$), sleep hours (weekday) ($p < 0.001$), sleep hours (weekend) ($p < 0.001$), and weekend catch-up sleep ($p < 0.001$). Among the health-related behaviors where significant differences were observed, behaviors with higher proportions in the OSA high-risk group compared to their original rates included: former smoker, current smoker, monthly drinking, high-risk drinking, sedentary time ≥ 7 h, frequency of eating out ≥ 3 times per week, skipping breakfast, consuming

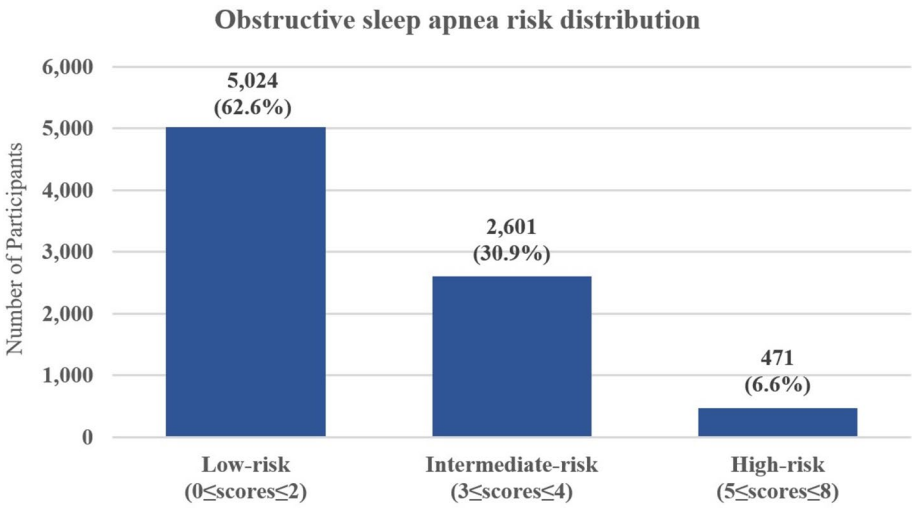

Fig. 2. Obstructive sleep apnea risk distribution.

Variable/classification	Total	Obstructive sleep apnea			
		Low risk (scores ≤ 2)	Intermediate risk (3 ≤ scores ≤ 4)	High risk (5 ≤ scores ≤ 8)	
		% (SE)	% (SE)	% (SE)	p-value
Age (years)					
40–49	28.6 (0.9)	36.5 (1.1)	15.0 (1.1)	17.9 (2.1)	< 0.001
50–59	30.0 (0.8)	28.3 (0.9)	30.9 (1.2)	42.2 (2.7)	
60–69	22.9 (0.6)	20.8 (0.7)	26.9 (1.0)	24.5 (2.1)	
≥ 70	18.4 (0.7)	14.5 (0.6)	27.2 (1.1)	15.4 (1.8)	
Sex					
Male	47.7 (0.6)	31.0 (0.7)	71.9 (1.0)	92.3 (1.3)	< 0.001
Female	52.3 (0.6)	69.0 (0.7)	28.1 (1.0)	7.7 (1.3)	
Number of household members					
1	12.3 (0.6)	11.6 (0.6)	14.0 (0.9)	11.2 (1.7)	0.015
≥ 2	87.7 (0.6)	88.4 (0.6)	86.0 (0.9)	88.8 (1.7)	
Living area					
Rural	17.3 (1.7)	15.4 (1.6)	20.3 (2.0)	20.8 (3.0)	< 0.001
Urban	82.7 (1.7)	84.6 (1.6)	79.7 (2.0)	79.2 (3.0)	
Educational status					
≤ Elementary	17.0 (0.7)	15.1 (0.7)	22.1 (1.1)	12.3 (1.5)	< 0.001
Middle to high school	44.5 (0.8)	43.7 (1.0)	44.7 (1.1)	50.0 (2.6)	
≥ University	38.5 (1.1)	41.2 (1.2)	33.2 (1.4)	37.7 (2.6)	
Economic activity					
None	38.6 (0.8)	39.8 (0.9)	38.7 (1.2)	27.1 (2.4)	< 0.001
Currently working	61.4 (0.8)	60.2 (0.9)	61.3 (1.2)	72.9 (2.4)	
Family income					
Low	12.6 (0.6)	10.9 (0.6)	16.4 (0.9)	11.0 (1.6)	< 0.001
Middle low	18.1 (0.7)	16.6 (0.7)	22.2 (1.1)	13.3 (1.6)	
Middle	20.7 (0.7)	21.3 (0.8)	18.5 (0.9)	25.2 (2.4)	
Middle high	22.9 (0.7)	24.3 (0.8)	20.4 (1.0)	20.6 (2.1)	
High	25.7 (1.0)	26.9 (1.2)	22.5 (1.3)	30.0 (2.4)	

Table 1. Obstructive sleep apnea (OSA) risk factors based on general characteristics (N = 8069).

Variable/classification	Total	Obstructive sleep apnea			
		Low-risk (scores ≤ 2)	Intermediate-risk (3 ≤ scores ≤ 4)	High-risk (5 ≤ scores ≤ 8)	
		% (SE)	% (SE)	% (SE)	p-value
BMI, kg/m^2					
< 23	37.1 (0.7)	46.2 (0.9)	24.6 (1.0)	8.0 (1.4)	< 0.001
23–25	24.4 (0.6)	24.9 (0.7)	26.0 (0.9)	11.9 (1.6)	
≥ 25	38.6 (0.7)	28.8 (0.8)	49.4 (1.2)	80.1 (2.1)	
Waist circumference, cm					
≥ 90 cm (men), ≥ 85 cm (women)	40.2 (0.7)	29.3 (0.8)	53.3 (1.3)	82.7 (1.9)	< 0.001
< 90 cm (men), < 85 cm (women)	59.8 (0.7)	70.7 (0.8)	46.7 (1.3)	17.3 (1.9)	
Hypertension					
Normal	56.0 (0.8)	71.1 (0.8)	33.8 (1.2)	16.9 (2.0)	< 0.001
Prehypertension	30.2 (0.7)	20.9 (0.7)	44.2 (1.3)	53.8 (2.6)	
Hypertension	13.7 (0.6)	8.0 (0.4)	22.0 (1.3)	29.3 (2.5)	
Diabetes					
Normal	37.5 (0.7)	44.8 (0.9)	26.4 (1.1)	20.1 (2.3)	< 0.001
Prediabetes	44.5 (0.7)	42.8 (0.8)	47.5 (1.2)	46.9 (2.6)	
Diabetes	18.0 (0.5)	12.4 (0.5)	26.1 (1.0)	33.0 (2.5)	
Dyslipidemia					
No	49.3 (0.7)	56.3 (0.8)	39.7 (1.2)	27.3 (2.3)	< 0.001
Yes	50.7 (0.7)	43.7 (0.8)	60.3 (1.2)	72.7 (2.3)	

Table 2. Obstructive sleep apnea risk based on metabolic characteristics (N = 8.069).

breakfast 5–7 times per week, weekday sleep duration < 6 h or 6–8 h, weekend sleep duration < 6 h or 6–8 h, and absence of catch-up sleep or catch-up sleep of ≥ 2 h.

Table 4 presents the results of the analysis utilizing logistic regression, examining the association between health-related behaviors and high-risk OSA. Initially, Model 1 was derived by adjusting for age and sex. In Model 1, "former smokers" showed 1.721 times higher OR risk than "never smokers" ($p = 0.002$, 95% CI). High-risk drinking and aerobic physical activity showed 1.739 times higher OR ($p < 0.001$, 95% CI), and 1.312 times higher OR ($p = 0.021$, 95% CI), respectively.

Subsequently, Model 2 was derived by adjusting for age, sex, number of household members, living area, educational status, economic activity, family income, BMI, waist circumference, hypertension, diabetes, and dyslipidemia in logistic regression analysis. After adjusting for general and metabolic characteristics, former smokers showed 1.643 times higher OR ($p = 0.007$, 95% CI) for OSA high risk, and high-risk drinkers showed 1.365 times higher OR ($p = 0.045$, 95% CI) for OSA high risk.

Discussion

In this study, we investigated the association between health-related behaviors and the high risk for OSA in the Korean adult population using data on general characteristics, metabolic characteristics, health-related behaviors, and OSA risk using KNHANES data. First, we assessed the study participants' OSA risk level based on the STOP-Bang score. The high-risk group was found to be 6.6%. Although there is no precise prevalence rate for OSA risk in South Korea, previous research[4] suggests that the estimated prevalence of OSA in the Korean population aged 30–69 years is 28.4%, with 11.3% classified as moderate to severe OSA. Despite a lower proportion of OSA high-risk groups in our study compared to the estimated prevalence, previous studies targeting the general population[11] had a STOP-Bang score of ≥ 3 and a sensitivity of 66.2% for detecting AHI ≥ 15 and 69.2% for detecting AHI ≥ 30. Therefore, it appears that not only the OSA high-risk group but also the intermediate-risk group, which accounted for 30.9%, may require diagnosis for OSA. Furthermore, as the STOP-Bang questionnaire includes items such as snoring, tiredness, and observed apnea[10], which are subjective or require someone else's observation, there is a risk of underreporting scores if there is no one to observe or if individuals are not aware of their symptoms.

Among the variables of general characteristics, metabolic characteristics, and health-related behaviors, several noteworthy variables showed differences depending on the level of OSA risk. First, our study shows that the frequency of risk for OSA was high among individuals in their 50 s and 60 s; however, as the age factor reached 70 years and above, the proportion decreased in our study. Reportedly, OSA increases with age[13]; however, according to a previous study that investigated the differential impact of obesity on OSA[36], middle-aged individuals diagnosed with OSA showed a higher likelihood of obesity based on anthropometric measurements compared with younger (< 30 years old) or older people (> 70 years old). In the STOP-Bang questionnaire, where items related to obesity such as BMI, neck circumference, and waist circumference were measured[10], among individuals aged 70 years and above, there appears to be a weak association between obesity and OSA compared with middle-aged individuals[36], indicating a potential underreporting of OSA risk. Therefore, further

Variable		Total	Obstructive sleep apnea			p-value
			Low-risk	Intermediate-risk	High-risk	
			% (SE)	% (SE)	% (SE)	
Smoking status	Never smoker	59.2 (0.6)	71.6 (0.7)	41.9 (1.1)	21.4 (2.1)	< 0.001
	Former smoker	25.4 (0.5)	16.5 (0.6)	37.4 (1.1)	53.8 (2.8)	
	Current smoker	15.4 (0.5)	11.9 (0.6)	20.7 (1.0)	24.8 (2.2)	
Exposure to secondhand smoking at home or workplace	None	91.8 (0.4)	92.1 (0.5)	91.8 (0.6)	88.9 (1.8)	0.126
	Have	8.2 (0.4)	7.9 (0.5)	8.2 (0.6)	11.1 (1.8)	
Monthly drinking	No	51.2 (0.7)	56.1 (0.9)	45.0 (1.2)	33.4 (2.6)	< 0.001
	Yes	48.8 (0.7)	43.9 (0.9)	55.0 (1.2)	66.6 (2.6)	
High-risk drinking	No	88.4 (0.5)	91.5 (0.5)	85.5 (0.9)	73.4 (2.3)	< 0.001
	Yes	11.6 (0.5)	8.5 (0.5)	14.5 (0.9)	26.6 (2.3)	
Aerobic physical activity	No	57.9 (0.7)	57.1 (0.9)	58.7 (1.1)	62.0 (2.6)	0.120
	Yes	42.1 (0.7)	42.9 (0.9)	41.3 (1.1)	38.0 (2.6)	
Sedentary time(hours/day)	< 7 h	39.7 (0.8)	41.3 (0.9)	37.8 (1.3)	33.1 (2.6)	0.002
	≥ 7 h	60.3 (0.8)	58.7 (0.9)	62.2 (1.3)	66.9 (2.6)	
Frequency of eating out	Rarely (< 1 time/month)	10.7 (0.5)	10.3 (0.5)	12.4 (0.8)	6.7 (1.2)	< 0.001
	Sometimes (1–3 times/month)	23.3 (0.6)	23.9 (0.8)	23.4 (0.9)	17.2 (1.9)	
	1–2 times/week	23.6 (0.5)	25.1 (0.7)	21.5 (0.9)	18.8 (2.1)	
	≥ 3 times/week	42.4 (0.8)	40.7 (0.9)	42.7 (1.3)	57.3 (2.6)	
Breakfast skipping	Never have breakfast	14.2 (0.5)	15.3 (0.7)	11.8 (0.9)	14.8 (2.0)	< 0.001
	Eat 1–2 times/week	9.9 (0.5)	10.9 (0.6)	8.0 (0.7)	8.9 (1.5)	
	Eat 3–4 times/week	8.5 (0.4)	8.9 (0.5)	8.0 (0.7)	6.8 (1.6)	
	Eat 5–7 times/week	67.5 (0.7)	65.0 (0.9)	72.2 (1.1)	69.5 (2.5)	
Use of nutrition labeling	No	72.5 (0.6)	67.4 (0.8)	80.8 (1.0)	81.0 (2.1)	< 0.001
	Yes	27.5 (0.6)	32.6 (0.8)	19.2 (1.0)	19.0 (2.1)	
Sleep hours (weekday)	< 6 h	16.7 (0.5)	15.4 (0.6)	19.1 (0.9)	18.3 (2.1)	< 0.001
	6–8 h	57.8 (0.7)	59.7 (0.8)	53.7 (1.1)	58.6 (2.6)	
	> 8 h	25.5 (0.6)	24.9 (0.8)	27.2 (1.0)	23.1 (2.2)	
Sleep hours (weekend)	< 6 h	11.9 (0.5)	10.7 (0.5)	14.5 (0.8)	12.1 (1.7)	< 0.001
	6–8 h	44.7 (0.7)	44.5 (0.8)	44.0 (1.1)	50.0 (2.9)	
	> 8 h	43.4 (0.7)	44.8 (0.9)	41.5 (1.1)	37.9 (2.9)	
Weekend catch-up sleep	No catch-up sleep	67.0 (0.8)	63.8 (1.0)	72.9 (1.2)	69.7 (2.7)	< 0.001
	< 1 h	2.4 (0.3)	2.6 (0.3)	2.2 (0.4)	1.1 (0.5)	
	1–2 h	15.0 (0.5)	16.8 (0.7)	12.2 (0.9)	12.2 (1.9)	
	> 2 h	15.6 (0.6)	16.8 (0.7)	12.7 (0.9)	17.0 (2.2)	

Table 3. STOP-Bang scores based on health-related behaviors.

investigation is needed to understand if there are distinct characteristics of OSA that differentiate advanced years from middle age. Furthermore, prevalence in high-risk OSA group was elevated when two or more individuals live together compared to those living alone. This could be attributed to the possibility that the risk for OSA may be underestimated in individuals living alone, as there may be no one to witness the person's snoring or apneas. One study[37] described social connections as factors that encourage individuals to seek diagnosis for OSA and adhere to treatments such as continuous positive airway pressure. People who live alone may be vulnerable in such support systems. In other words, individuals who live alone may have difficulty detecting the risk for OSA in a timely manner and may also be vulnerable in managing OSA. Thus, additional attention is required for one-person households in Korea. Notably, the high-risk group showed a higher proportion of individuals with high income levels. Considering the evidence that sleep complaints of snoring are more commonly reported among high income individuals[38], and research results indicating a poor definition of OSA in low income groups[39], individuals in the high income group were more frequently classified as the high-risk group in this study because they showed greater awareness and reported their own OSA symptoms accurately.

In terms of metabolic characteristics, the elevated risk for OSA observed among individuals with higher BMI and waist circumference can be explained based on the strong association between OSA and obesity[15]. As anticipated, individuals with metabolic disorders such as hypertension, diabetes, and dyslipidemia exhibited a higher prevalence of OSA risk. However, within the OSA high-risk group, there was an increased proportion of individuals in the pre-hypertension and pre-diabetes stages. This underscores the importance of early management to prevent progression to full hypertension and diabetes and highlights the need for disease management from the early stages.

Variables		Model 1		Model 2	
		OR (95% CI)	*p* value	OR (95% CI)	*p* value
Smoking status	Never smoker	1		1	
	Former smoker	1.721 (1.232–2.404)	0.002	1.643 (1.148–2.353)	0.007
	Current smoker	1.289 (0.922–1.802)	0.137	1.246 (0.853–1.818)	0.254
Secondhand smoking	None	1		1	
	Have	1.284 (0.869–1.897)	0.779	1.404 (0.944–2.088)	0.093
Monthly drinking	No	1		1	
	Yes	1.208 (0.939–1.555)	0.141	0.971 (0.740–1.273)	0.829
High-risk drinking	No	1		1	
	Yes	1.739 (1.321–2.289)	< 0.001	1.365 (1.006–1.850)	0.045
Aerobic physical activity	No	1.312 (1.042–1.653)	0.021	1.172 (0.906–1.517)	0.226
	Yes	1		1	
Sedentary time	< 7 h	1		1	
	≥ 7 h	1.299 (1.029–1.641)	0.029	1.219 (0.935–1.588)	0.143
Frequency of eating out	rarely (< 1 time/month)	1		1	
	Sometimes (1–3 times/month)	1.058 (0.666–1.681)	0.810	1.066 (0.662–1.717)	0.791
	1–2 times/week	1.118 (0.690–1.812)	0.650	1.031 (0.615–1.731)	0.907
	≥ 3 times/week	1.261 (0.779–2.042)	0.344	1.222 (0.739–2.019)	0.434
Breakfast skipping	Eat 5–7 times/week	1		1	
	Eat 3–4 times/week	0.767 (0.455–1.294)	0.455	0.581 (0.320–1.054)	0.074
	Eat 1–2 times/week	0.967 (0.639–1.461)	0.639	0.879 (0.566–1.363)	0.563
	Never have breakfast	1.138 (0.806–1.608)	0.806	0.920 (0.628–1.349)	0.670
Use of nutrition labeling	No	1.071 (0.792–1.449)	0.654	0.982 (0.700–1.377)	0.914
	Yes	1		1	
Sleep hours (weekday)	< 6 h	1.158 (0.856–1.566)	0.342	0.981 (0.714–1.348)	0.907
	6–8 h	1		1	
	> 8 h	0.928 (0.710–1.213)	0.585	0.867 (0.653–1.151)	0.323
Sleep hours (weekend)	< 6 h	1.011 (0.705–1.449)	0.954	0.913 (0.629–1.323)	0.629
	6–8 h	1		1	
	> 8 h	0.806 (0.620–1.048)	0.107	0.796 (0.607–1.046)	0.101
Weekend catch-up sleep	No catch-up sleep	1		1	
	< 1 h	0.572 (0.220–1.484)	0.250	0.776 (0.277–2.174)	0.629
	1–2 h	0.844 (0.564–1.263)	0.408	1.012 (0.651–1.571)	0.959
	> 2 h	1.020 (0.735–1.417)	0.905	1.012 (0.707–1.448)	0.948

Table 4. Association between obstructive sleep apnea (OSA) and health-related behaviors. Model 1: Adjusted for age and sex. Model 2: Adjusted for age, sex, number of household members, living area, educational status, economic activity, family income, BMI, waist circumference, hypertension, diabetes, and dyslipidemia.

As regards health-related behaviors, smoking status showed a significant difference according to the associated OSA risk; however, statistically no significant difference was observed in the risk for OSA between individuals exposed to secondhand smoking at home or workplace. A mere 8.2% of our survey respondents reported exposure to secondhand smoking. Statistics show that Korea experienced a notable decrease in the prevalence of secondhand smoke following the expansion of non-smoking areas in 2012[40]. Between 2007 and 2019, the prevalence of secondhand smoke exposure at home among Korean adults aged 19 years and above decreased from 14.7 to 4.7%, while exposure in indoor workplaces decreased from 46.0 to 14.1%[40]. With the substantial nationwide decline in secondhand smoke exposure, it is plausible that there is no discernible difference in OSA risk associated with exposure to secondhand smoking. In our study, variables for sedentary time and frequency of eating out showed differences based on the level of OSA risk. Aligning with previous studies[33,34], these findings show that sedentary time and eating out frequency are associated with weight gain; hence, it is believed that individuals in the high-risk OSA group were more likely to spend 7 or more hours either sitting or lying down per day and eating out three or more times a week in our study. Interestingly, our findings revealed higher proportions in two contrasting groups within the OSA high-risk category: those who never consumed breakfast and those who consumed breakfast almost every day (5 times a week or more). Considering previous research findings indicating that breakfast skipping is a negative predictor of obesity[33] and lower AHI[41], the higher prevalence of individuals at high risk for OSA in the group that never had breakfast can be explained. However, surprisingly, there was a high prevalence of individuals who consume breakfast more than five times per week in the OSA high-risk group. Research indicates that it is not only about whether individuals eat breakfast but also what they eat for breakfast is related to obesity and metabolic syndrome[42]; therefore, there is a need for a multifaceted

analysis to investigate not only the frequency of eating breakfast but also the nutritional quality and quantity of food consumed. Regarding sleep-related variables, an increased proportion of individuals reported sleeping 6 h or less, and those sleeping between 6 and 8 h in the OSA high-risk group. However, contrary to previous studies suggesting an association between long hours of sleep duration (9 h or more) and obesity in men[43], our findings differed. In our study, the reason for a higher prevalence of individuals sleeping 8 h or less in the high-risk OSA group can be explained by the fact that OSA can lead to frequent arousal and poor sleep quality[44]. Therefore, individuals in the OSA high-risk group may have had a shorter sleep duration. However, a comprehensive evaluation of not only objective sleep quantity but also subjective sleep quality is warranted.

Despite controlling all the subject characteristics that showed significant differences in OSA risk, associations were established in the smoking and drinking categories. Regarding drinking, our result aligns with the findings of a systematic review[18] on the association between alcohol consumption and OSA risk. The study explained that compared to the group that did not consume alcohol, the risk for OSA was exacerbated in the group that consumed alcohol[18]. However, the study integrated literature using PSG results as a risk indicator for OSA[18] while we employed the STOP-Bang questionnaire. Despite this difference, similar results were obtained. Regarding alcohol consumption increasing the risk for OSA, it is clarified that alcohol intake, acting as a sedative, can depress neural mechanisms that are responsible for the respiratory activity of the genioglossus, thus leading to prolonged apnea duration [45]. Monthly alcohol consumption did not show a significant association with risk for OSA; however, a relationship was observed in high-risk drinkers with increased alcohol consumption, implying that the risk for OSA exacerbates with the amount and intensity of alcohol intake.

With respect to smoking, former smokers were associated with an elevated risk for OSA, while there was no association observed for current smokers. It can be interpreted that the risk for OSA is higher in former smokers than current smokers, potentially diluting the positive impact of smoking cessation[46]. However, these results suggest that a more detailed investigation into the phenomenon is warranted. For example, former smokers may have quit smoking owing to other health issues, which could possibly have led to an increase in the risk for OSA. Indeed, studies show former smokers mentioning their current health condition as the primary reason for quitting smoking[46,47]. In a previous study[46], it was found that 43.2% of former smokers had ceased smoking owing to health issues, and these individuals were observed to have smoked for longer durations and consumed a greater number of cigarettes per day. The identification of an association between OSA risk and former smokers in our study may be attributed to the potential development of chronic conditions among former smokers, such as chronic obstructive pulmonary disease, as smoking is a powerful risk factor for the disease[48]. Alternatively, the total duration of smoking or the total amount smoked may play a more significant role than the current smoking status. A meta-analysis investigating the association between smoking and OSA[49] establishes an correlation between OSA and individuals who have smoked 20 pack-years or more. As this study only examined the smoking status, there may have been an undetected difference in pack-years between current and former smokers. The above-discussed points require further investigation.

This study has certain limitations as it has used a cross-sectional design, indicating that causal explanations are not possible. It only investigated the extent of the association between health-related behaviors and OSA risk but does not explain how health-related behaviors contribute to the risk for OSA. Secondly, it was impractical to include all variables that could potentially be associated with OSA in our study. This limitation arises from the constraints inherent in secondary data analysis study. Therefore, future research is warranted to comprehensively investigate health-related behaviors, diseases, and general characteristics associated with OSA that were beyond the scope of our study. Lastly, we did not consider the possible interactions between health-related behaviors. However, this study used systematically sampled objective data representative of South Korea, thus increasing the accuracy and generalizability of the results. A time- and cost-effective OSA screening questionnaire and larger sample sizes were used, further enhancing the generalizability of the research. We suggest conducting broader studies using other variables to identify health-related behaviors that influence OSA risk.

To mitigate the adverse health outcomes and societal burden associated with OSA, it is imperative to implement lifestyle-modifying interventions that can effectively prevent and manage this condition. Moreover, it is crucial to investigate modifiable health-related behaviors that have the potential to increase the risk for OSA and incorporate them into nursing intervention strategies. Nursing interventions should prioritize addressing the problem of high-risk drinking and smoking, ensuring a targeted approach to addressing the significant link to OSA.

Implications for nursing

This study highlights several important implications for nursing practice, particularly in the context of preventing and managing OSA in the Korean adult population. The association between health-related behaviors and OSA risk underscores the need for comprehensive and targeted nursing interventions.

Nursing interventions should prioritize high-risk behaviors such as smoking and excessive alcohol consumption, incorporate smoking cessation programs and education on high-risk drinking. Nurses should also focus on the vulnerability of individuals living alone by including community outreach programs and support systems to aid in the detection and management of OSA symptoms. Routine screenings for pre-hypertension and prediabetes should be emphasized, along with education on lifestyle modifications to prevent disease progression. Furthermore, a multifaceted approach to dietary behaviors is necessary, promoting balanced and nutritious food choices. Finally, encouraging physical activity and reducing sedentary time should be integral parts of nursing interventions to mitigate OSA risk.

In conclusion, the implications for nursing practice derived from this study advocate for a holistic and proactive approach in addressing the risk factors associated with OSA. By integrating targeted health education, lifestyle modification programs, and community support initiatives, nurses can contribute to the prevention and

management of OSA, eventually improving patient outcomes and reducing the societal burden of this condition. Further research should continue to explore effective nursing strategies to address these health-related behaviors and their impact on OSA risk.

Data availability

The datasets generated during and/or analysed during the current study are available in the Korea Centers for Disease Control and Prevention repository, https://knhanes.kdca.go.kr/knhanes/sub03/sub03_02_05.do.

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References

1. Punjabi, N. M. The epidemiology of adult obstructive sleep apnea. *Proc. Am. Thorac. Soc.* **5**, 136–143 (2008).
2. Jordan, A. S., McSharry, D. G. & Malhotra, A. Adult obstructive sleep apnoea. *Lancet* **383**, 736–747 (2014).
3. Wimms, A. et al. Obstructive sleep apnea in women: Specific issues and interventions. *Biomed. Res. Int.* **2016**, 1764837 (2016).
4. Benjafield, A. V. et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: A literature-based analysis. *Lancet Respir. Med.* **7**, 687–698 (2019).
5. Lee, M. R. & Jung, S. M. Obstructive sleep apnea related to mental health, health-related quality of life and multimorbidity: A nationwide survey of a representative sample in Republic of Korea. *PLoS ONE* **18**, e0287182 (2023).
6. Vanek, J. et al. Obstructive sleep apnea, depression and cognitive impairment. *Sleep Med.* **72**, 50–58 (2020).
7. Gao, J., Shi, L., Zhu, X. & Liu, J. Association of obstructive sleep apnea with cardiometabolic diseases and cardiovascular mortality. *Clin. Respir. J.* **17**, 764–770 (2023).
8. Phua, C. Q. et al. Reducing cost and time to diagnosis and treatment of obstructive sleep apnea using ambulatory sleep study: A Singapore sleep centre experience. *Sleep Breath.* **25**, 281–288 (2021).
9. Medicine, A. Sleep-related breathing disorders in adults: Recommendations for syndrome definition and measurement techniques in clinical research. The report of an American Academy of Sleep Medicine task force. *Sleep* **22**, 667–689 (1999).
10. Chung, F. et al. STOP questionnaire: A tool to screen patients for obstructive sleep apnea. *Anesthesiology* **108**, 812–821 (2008).
11. Tan, A. et al. Predicting obstructive sleep apnea using the STOP-Bang questionnaire in the general population. *Sleep Med.* **27**, 66–71 (2016).
12. Huh, G. et al. Comorbidities associated with high-risk obstructive sleep apnea based on the STOP-BANG questionnaire: A nationwide population-based study. *Korean J. Intern. Med.* **38**, 80–92 (2022).
13. Senaratna, C. V. et al. Prevalence of obstructive sleep apnea in the general population: A systematic review. *Sleep Med. Rev.* **34**, 70–81 (2017).
14. Votteler, S. et al. Sex differences in polysomnographic findings in patients with obstructive sleep apnea. *Sleep Med.* **101**, 429–436 (2023).
15. Deflandre, E. et al. Risk factors for nocturnal hypoxemia in severe obstructive sleep apnea patients. *Minerva Anestesiol.* **83**, 449–456 (2017).
16. Kim, D. H., Kim, B., Han, K. & Kim, S. W. The relationship between metabolic syndrome and obstructive sleep apnea syndrome: A nationwide population-based study. *Sci. Rep.* **11**, 8751 (2021).
17. Jang, Y. S., Nerobkova, N., Hurh, K., Park, E. C. & Shin, J. Association between smoking and obstructive sleep apnea based on the STOP-Bang index. *Sci. Rep.* **13**, 9085 (2023).
18. Yang, S. et al. Alcohol as an independent risk factor for obstructive sleep apnea. *Irish J. Med. Sci.* **191**, 1325–1330 (2022).
19. Choi, Y. et al. Association of dietary behaviors with poor sleep quality and increased risk of obstructive sleep apnea in Korean military service members. *Nat. Sci. Sleep* **14**, 1737–1751 (2022).
20. Hall, K. A., Singh, M., Mukherjee, S. & Palmer, L. J. Physical activity is associated with reduced prevalence of self-reported obstructive sleep apnea in a large, general population cohort study. *J. Clin. Sleep Med.* **16**, 1179–1187 (2020).
21. Gochman, D. S. Health behavior: Plural perspectives. In *Health Behavior: Emerging Research Perspectives*, 3–17 (Springer, 1988).
22. Kim, K., Shin, S., Kim, S. & Lee, E. The relation between eHealth literacy and health-related behaviors: Systematic review and meta-analysis. *J. Med. Internet Res.* **25**, e40778 (2023).
23. Duan, X. et al. Association of healthy lifestyle with risk of obstructive sleep apnea: A cross-sectional study. *BMC Pulm. Med.* **22**, 33 (2022).
24. Nagappa, M., Wong, J., Singh, M., Wong, D. T. & Chung, F. An update on the various practical applications of the STOP-Bang questionnaire in anesthesia, surgery, and perioperative medicine. *Curr. Opin. Anaesthesiol.* **30**, 118–125 (2017).
25. Oshita, H. et al. The STOP-Bang test is useful for predicting the severity of obstructive sleep apnea. *JMA J.* **3**, 347–352 (2020).
26. World Health Organization. *The Asia-Pacific Perspective: Redefining Obesity and Its Treatment* (*Health Communications, Sydney*, 2000).
27. Kim, B. Y. et al. 2020 Korean Society for the Study of Obesity guidelines for the management of obesity in Korea. *J. Obes. Metab. Syndr.* **30**, 81–92 (2021).
28. Cho, S. M. J. et al. Dyslipidemia fact sheets in Korea 2020: An analysis of nationwide population-based data. *J. Lipid Atheroscler.* **10**, 202–209 (2021).
29. Korea Centers for Disease Control and Prevention. Agency. The 8th KNHANES: data Analysis Guidelines. https://knhanes.kdca.go.kr/knhanes/sub03/sub03_06_02.do.
30. Matthews, C. E. et al. Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *Am. J. Clin. Nutr.* **95**, 437–445 (2012).
31. Xu, C. et al. Sedentary behavior, physical activity, and all-cause mortality: Dose-response and intensity weighted time-use meta-analysis. *J. Am. Med. Dir. Assoc.* **20**, 1206-1212.e1203 (2019).
32. Bhutani, S., Schoeller, D. A., Walsh, M. C. & McWilliams, C. Frequency of eating out at both fast-food and sit-down restaurants was associated with high body mass index in non-large metropolitan communities in Midwest. *Am. J. Health Promot.* **32**, 75–83 (2018).
33. Ma, X. et al. Skipping breakfast is associated with overweight and obesity: A systematic review and meta-analysis. *Obes. Res. Clin. Pract.* **14**, 1–8 (2020).
34. Nieto, C. et al. Nutrition label use is related to chronic conditions among Mexicans: Data from the Mexican National Health and Nutrition survey 2016. *J. Acad. Nutr. Diet.* **120**, 804–814 (2020).
35. Xie, J. et al. Sleep duration and metabolic syndrome: An updated systematic review and meta-analysis. *Sleep Med. Rev.* **59**, 101451 (2021).
36. Lee, Y. G., Lee, Y. J. & Jeong, D.-U. Differential effects of obesity on obstructive sleep apnea syndrome according to age. *Psychiatry Investig.* **14**, 656–661 (2017).

37. Sawyer, A. M. et al. Differences in perceptions of the diagnosis and treatment of obstructive sleep apnea and continuous positive airway pressure therapy among adherers and nonadherers. *Qual. Health Res.* **20**, 873–892 (2010).
38. Hirotsu, C., Bittencourt, L., Garbuio, S., Andersen, M. L. & Tufik, S. Sleep complaints in the Brazilian population: Impact of socioeconomic factors. *Sleep Sci.* **7**, 135–142 (2014).
39. Sia, C. H. et al. Awareness and knowledge of obstructive sleep apnea among the general population. *Sleep Med.* **36**, 10–17 (2017).
40. Korea Disease Control and Prevention Agency. *<Noncommunicable Disease (NCD) Statistics> Exposure rates to secondhand smoke among Korean adults aged 19 and over 2007–2019* (Div. of Chronic Disease Control, Korea Disease Control and Prevention Agency). (2021).
41. de Melo, C. M. et al. Relationship of evening meal with sleep quality in obese individuals with obstructive sleep apnea. *Clin. Nutr. ESPEN* **29**, 231–236 (2019).
42. Chung, S. J., Lee, Y., Lee, S. & Choi, K. Breakfast skipping and breakfast type are associated with daily nutrient intakes and metabolic syndrome in Korean adults. *Nutr. Res. Pract.* **9**, 288–295 (2015).
43. Liu, W. et al. Long sleep duration predicts a higher risk of obesity in adults: A meta-analysis of prospective cohort studies. *J. Public Health* **41**, e158–e168 (2019).
44. Badran, M., Yassin, B. A., Fox, N., Laher, I. & Ayas, N. Epidemiology of sleep disturbances and cardiovascular consequences. *Can. J. Cardiol.* **31**, 873–879 (2015).
45. Krol, R. C., Knuth, S. L. & Bartlett, D. Jr. Selective reduction of genioglossal muscle activity by alcohol in normal human subjects. *Am. Rev. Respir. Dis.* **129**, 247–250 (1984).
46. Gallus, S. et al. Why do smokers quit?. *Eur. J. Cancer Prev.* **22**, 96–101 (2013).
47. Buczkowski, K., Marcinowicz, L., Czachowski, S. & Piszczek, E. Motivations toward smoking cessation, reasons for relapse, and modes of quitting: Results from a qualitative study among former and current smokers. *Patient Preference Adherence* **8**, 1353–1363 (2014).
48. Adeloye, D. et al. Global, regional, and national prevalence of, and risk factors for, chronic obstructive pulmonary disease (COPD) in 2019: A systematic review and modelling analysis. *Lancet Respir. Med.* **10**, 447–458 (2022).
49. Zeng, X. et al. Association between smoking behavior and obstructive sleep apnea: A systematic review and meta-analysis. *Nicotine Tob. Res.* **25**, 364–371 (2023).

Author contributions

YC and JK conceptualized and wrote the main manuscript text. YC prepared Figs. 1 and 2. All authors reviewed the manuscript.

Competing interests

The authors declare no competing interests.

Ethical consideration

This is a secondary data analysis study that used national open data collected previously from individuals after written informed consent was obtained at the time of data acquisition. Publicly available raw data do not contain personally identifiable information and are disclosed in the form of statistics. Therefore, no separate consent procedures were undertaken for this study, as a review exemption was received from the Institutional Review Board (IRB) of Chung-Ang University (No. 1041078-20240329-HR-064).

Additional information

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