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Associations of dual use of tobacco cigarettes and e-cigarettes, sleep duration, physical activity and depressive symptoms among middle-aged and older Korean adults

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Abstract

Aim: There is limited evidence of the association between dual tobacco–e-cigarette use and health-related variables in Korea. Thus, this study aimed to investigate the associations between types of cigarette smoking, sleep duration, physical activity and depressive symptoms among Korean adults.

Design: A cross-sectional study design using the 2019 Korean Community Health Survey.

Methods: The study subjects consisted of 179,004 adults older than 40 years from a total of 229,099 individuals. Self-reported general characteristics, smoking history, sleep duration, physical activity and depressive symptoms were analysed.

Results: In multinomial logistic regression, dual users of tobacco cigarettes and e-cigarettes were more likely to have sleep duration of less than 7 h per day and to report both mild and moderate-to-severe depressive symptoms than non-smokers. Single use of either cigarettes or e-cigarettes increased the risk of short sleep duration and moderate-to-severe depressive symptoms.

KEYWORDS

adults, depressive symptoms, physical activity, sleep duration, smoking

1 | INTRODUCTION

Cigarette smoking is a major risk factor for various chronic illnesses, such as cardiovascular disease, cancer and respiratory diseases (Morean et al., 2018). In South Korea, 21.5% of the adult population smokes daily or occasionally; 35.7% of men and 6.7% of women are current cigarette smokers (Korea Disease Control and Prevention Agency, 2021). Recently, electronic cigarettes (e-cigarettes) have gained popularity as less harmful than the tobacco cigarettes or have been used to aid smoking cessation (Morean et al., 2018). Since the introduction of e-cigarettes as smoking cessation agents in Korea in 2007 (Kim, Kang, & Cho, 2020; Kim, Paek, et al., 2020), e-cigarette use among men in Korea reached 11.3% in 2018, indicating a five-fold increase since 2013 (Kim et al., 2021). However, there is a lack of knowledge about the long-term harmful effects of e-cigarettes or the synergistic effects of dual use of tobacco cigarettes and e-cigarettes at the population level in the Republic of Korea. As many cigarettes smokers are dual users of both tobacco cigarettes and e-cigarettes (Piper et al., 2019; Wang et al., 2018), these users may be exposed to greater health risks (Oakly & Martin, 2019) and may have increased risks of cardiovascular and chronic respiratory diseases (Kim, Kang, & Cho, 2020; Kim, Paek, et al., 2020; Wang et al., 2018). Moreover,

dual users tend to have the greater nicotine dependence than tobacco cigarette-only smokers if they continue to use both tobacco cigarettes and e-cigarettes (Kim, Kang, & Cho, 2020; Kim, Paek, et al., 2020). In the United States, nearly 70% of the current adult e-cigarette users also smoked cigarettes (Baig & Giovenco, 2020). In a survey of New Zealanders aged 45 years or more, 63.9% of e-cigarette users were identified as dual users (Oakly & Martin, 2019). Despite the recent trend of the rapidly increasing number of dual-user population worldwide, the health effects of such dual use of cigarettes constitutes a relatively under-researched topic at present, as compared to studies that have evaluated the health effects of single use tobacco cigarettes or e-cigarettes (Wang et al., 2018). In addition, epidemiologic data on dual users and their health is limited and warrants further investigation.

Nurses can play a pivotal role in tobacco control by educating and promoting smoking cessation efforts in the general population (Newhouse et al., 2018). Nurses should be well-informed of the harms of the different types of cigarettes, which are associated with smoking-related chronic conditions such as cancer, cardiovascular disease and chronic pulmonary obstructive diseases (Russell et al., 2021). Nurses can motivate smoking cessation and identify the timing and modality of smoking cessation care (Newhouse et al., 2018; Russell et al., 2021). Importantly, many nurse-led smoking cessation interventions have increased the likelihood of quitting (Halcomb et al., 2015; Lu et al., 2019; Wong et al., 2018). Cumulative evidence suggests that nurses can effectively engage smokers in health behaviours (Halcomb et al., 2015). Therefore, nurses working in any setting in the healthcare sector need familiarization with the types and health risks of cigarette smoking to prevent adverse health outcomes in their people who required quality of care.

Sleep plays a critical role in immune and cardiovascular systems (Purani et al., 2019). Short (<6 h/day) and long (>9 h/day) sleep durations are particularly linked to an increased risk of memory impairment and cardiovascular disease (Purani et al., 2019). Current smokers reported significantly less total sleep time, difficulty in continuous sleep and waking up earlier than never smokers (Bae et al., 2018). A recent study showed that long sleep duration (>9 h) is more common among current smokers than never smokers (Boakye et al., 2018). Another study reported that current smokers are more likely to experience shorter sleep duration (Liao et al., 2019). However, few studies have examined sleep issues in dual users.

According to World Health Organization 2020 guidelines, physical inactivity has been defined as undertaking less than 30 minutes of moderate-intensity aerobic activity (e.g. brisk walking) (Bull et al., 2020). Smoking and physical inactivity are strongly related to adverse health outcomes, which increases the incidence of chronic diseases and all-cause and cardiovascular mortality (Swan et al., 2018). Smoking status is negatively associated with being either moderately or highly physically active (Song & Giovannucci, 2020) A study reported that the proportion of inadequate daily activity among smokers is higher than that among non-smokers (Jackson et al., 2019). Another study found that adolescents who had never smoked in the past month are more likely to be involved in moderate-to-vigorous-intensity activities as compared to adolescents who had smoked (Song & Giovannucci, 2020). However, the existing data on smoking and physical activity are mainly cross-sectional and, therefore, limited to the identification of causal relationships (Jackson et al., 2019; Song & Giovannucci, 2020).

With regard to mental health, dual users reported having a depressive mood that lasted longer than 2 weeks, compared to cigarette-only smokers and never smokers (Kim, Kang, & Cho, 2020; Kim, Paek, et al., 2020). Smoking and depressive symptoms may have a bidirectional association. Occasional smoking tends to initially alleviate depressive symptoms; however, ultimately, smoking worsens the symptoms over time (Fluharty et al., 2017). According to a recent review (Weinberger et al., 2017), people with depressive symptoms are twice as likely to smoke cigarettes and have greater difficulty with smoking cessation. However, little is known about depressive symptoms among dual users in a sample of community-dwelling adults in Korea.

Considering the significant public health risks associated with smoking, there is an urgent need to understand the mechanisms and outcomes of dual use of cigarettes and e-cigarettes, to prepare appropriate, effective public health and policy responses. However, there is a lack of knowledge on the association between various types of cigarette smoking, including dual use of cigarettes and e-cigarettes, sleep duration, physical inactivity and depressive symptoms as compared to the quantum of research on the association between cigarette smoking and health risk behaviours in adults. Previous studies have reported that cigarette smoking is a major public concern as an important risk factor of all-cause mortality, in both middle-aged and older adults (Khosravi et al., 2018; Thun et al., 2013). However, studies of smoking status correlates in middle-aged and older adults in Korea are limited as compared to studies of younger populations (Kim, Kang, & Cho, 2020; Kim, Paek, et al., 2020; Lee et al., 2011).

Thus, there is a need for comprehensive, population-based research on the types of cigarette smoking and their relationship with other modifiable health risks. Assisting smokers to achieve smoking cessation is one of the most important services which nurses can offer to protect patient health now and in the future. This study, thus, aimed to investigate the associations between the types of cigarette smoking (single users of tobacco cigarette only or e-cigarette only, dual use of tobacco cigarette and e-cigarette, and non-smokers), sleep duration, physical inactivity, and depressive symptoms in community-dwelling adults aged 40 years or older by using information from a national data set.

2 | METHODS

2.1 | Study design and participants

We used data from the 2019 Korean Community Health Survey (KCHS), which comprised adults older than 19 years who were living in apartments and ordinary houses in each of the cities, counties and districts throughout the country. The KCHS is based on a two-stage stratified sampling of households. In the first stage, smaller sub-districts (Dong/Eup/Myeon) within each community were randomly selected

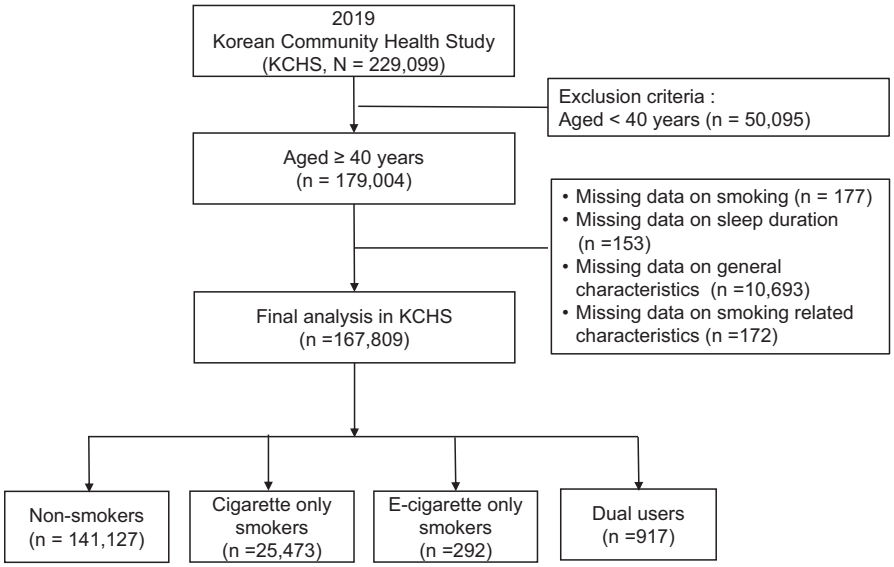

FIGURE 1 Flow chart of the participant-selection process in this study.

by the probability proportionate sampling. In the second stage, sample households were selected by a systematic sampling method.

Participants consisted of 179,004 adults older than 40 years from a total of 229,099 individuals who participated in the 2019 KCHS. The age of our participants ranged from 40 to 88. Individuals who did not respond to the questions on smoking (n = 177), sleep duration (n = 153), general characteristics (n = 10,693) and smoking-related characteristics (n = 172) were excluded. We analysed the data of 167,809 participants as a representative sample (Figure 1).

2.2 | Measures

2.2.1 | General characteristics of the participants

Sociodemographic and health-related characteristics included age, sex, marital status, education level, occupation, monthly family income, national basic livelihood recipient status, residential area, alcohol consumption, height, weight, hypertension and diabetes. Residential area was categorized into urban with Dong (neighbourhood) and rural with Eup (town) and Myeon (township). Body mass index (BMI) was calculated using respondents' height and weight. Based on the 2018 Korean Society for the Study of Obesity Guideline (Seo et al., 2019), BMI was classified into 'underweight' (<18.5 kg/m^2), 'healthy weight' (18.5–22.9 kg/m^2), 'overweight' (23.0–24.9 kg/m^2) and 'obese' (≥25.0 kg/m^2).

2.2.2 | Smoking status

Respondents were categorized as 'non-smokers', 'cigarette-only smokers', 'e-cigarette-only smokers' and 'dual users'. Non-smokers were those who had never smoked or had smoked in the past but did not smoke currently. Cigarette-only smokers were those who currently smoked every day or on some days, and those who selected 'no' to the question, 'During the past 30 days, have you used e-cigarettes with liquid nicotine?' E-cigarette only smokers were those who selected 'no' to the question, 'Have you smoked at least 100 cigarettes in your lifetime?', those who had smoked in the past but did not smoke currently, and those who selected 'yes' to the question, 'Have you used e-cigarettes with liquid nicotine during the past 30 days?' Dual users were those who currently smoked every day or on some days and who selected 'yes' to the question, 'During the past 30 days, have you used e-cigarettes with liquid nicotine?'

2.2.3 | Smoking-related characteristics

The age of *19* is the minimum legal age for purchasing and smoking tobacco products in Korea (Cho, 2014). Accordingly, age of smoking initiation was categorized as 'under 19 years old' and 'over 19 years old' considering their response to the question, 'How old were you when you smoked a cigarette for the first time?' The number of cigarettes smoked by current users (number of cigarettes smoked per day) was obtained by the question, 'How many cigarettes do you smoke per day on average?' Those who smoked 1–9 cigarettes were categorized as 'light smokers', 10–20 as 'medium smokers' and over 20 as 'heavy smokers'. (Zhao et al., 2015). Attempts to quit smoking were categorized as 'yes' or 'no' in response to the question, 'During the past 12 months, have you stopped smoking (tobacco) for 24 h or more because you were trying to quit?'

2.2.4 | Sleep duration, physical activity and depressive symptoms

Sleep duration was measured using a single-item self-report questionnaire: 'How many hours do you sleep daily?' Sleep duration was

categorized as <7 h, 7–8 h and ≥9 h based on the reference categories of the International Classification of Sleep Disorders (American Academy of Sleep Medicine, 2005).

The 2019 KCHS physical activity questionnaire was based on the short from of the Korean version of International Physical Activity Questionnaire (IPAQ-SF) (Oh et al., 2007). IPAQ-SF measures the frequency and duration of walking and other moderate-to-vigorous aerobic activity that was undertaken for more than 10 continuous minutes across all contexts (i.e. work, transport, household and leisure activities) in the previous 7 days (Lee et al., 2011). Data are expressed a metabolic equivalent task (MET, min/week) (Craig et al., 2003). Physical activity was categorized as 'inactive' (those who did not meet the criteria for 'minimally active group' or 'Health-Enhancing Physical Activity (HEPA) group'), 'minimally active (≥20 min of daily vigorous activity on ≥3 days, or ≥30 min of moderate-intensity activity or walking on ≥5 days, or vigorous-intensity activity on ≥5 days that summed to 600-2,999 MET-min/week)', and 'HEPA' (vigorous-intensity activity at least 3 days summing to ≥1500 MET-min/week or vigorous-intensity activity that summed to ≥3000 MET-min/week) (Lee et al., 2011; Oh et al., 2007).

Depressive symptoms were accessed with the Korean version of the Patient Health Questionnaire-9 (PHQ-9) (Park et al., 2010) with a nine-item self-report measure of depressive symptoms developed by Kroenke et al. (2001). Respondents were asked how much they had been bothered by each of the 9 items in the past 2 weeks; response options were not at all (0), several days (1), more than half the days (2) and nearly every day (3) (Kroenke et al., 2001). A score of 0–4 is considered minimal depressive symptoms, 5–9 as mild depressive symptoms and 10–27 as moderate-to-severe depressive symptoms (Park et al., 2010).

2.3 | Ethical considerations

This study was approved by the institutional review board of the principal author's university (IRB No. 1041078-202,108-HRSB-248-01). Obtaining informed consent was waived because the data in this database were de-identified.

2.4 | Statistical analysis

Data were analysed using IBM SPSS for Windows, version 26.0. For complex sample design, sampling weights were used to account for this design. Data were analysed after generating an analysis planning file using sample weights, stratification and clustering in accordance with the recommendations of the KCHS data analysis guidelines. Descriptive statistics were presented as a frequency (*n*) that did not reflect the weight and a percentage that reflected the weight (weighted %). The Rao–Scott χ^2 test was used to compare differences in participant characteristics, smoking-related characteristics, sleep duration, physical activity and depressive symptoms by smoking status (non-smokers vs. current smokers, single vs. dual users and non-smokers vs. single vs. dual users). Unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were computed using multinomial logistic regression with complex sample. We considered covariates if they were statistically significant in univariate analysis. As covariates, socioeconomic factors (age, sex, spouse, education, job, monthly family income and residency) and health-related factors (alcohol intake, hypertension and diabetes) were adjusted. Dependent variables consisted of sleep duration, physical inactivity and depressive symptoms. Each category of the current smokers (i.e. single user of cigarette or e-cigarette only, dual user of both cigarette and e-cigarette) was used as an independent variable, while the non-smoker group was used as a reference category. Hosmer-Lemeshow test for the goodness of fit of logistic regression was used to ensure appropriateness of the model. Statistical significance was set a priori at $p < 0.05$.

3 | RESTULS

3.1 | Participants' characteristics

Table 1 shows the general characteristics of the sample ($n = 167,809$). Most participants were in the 40–64 age group (71.7%, $n = 99,007$). Most were women (51.4%, $n = 93,409$). Regarding smoking status, 15.9% (26,682/167,809) reported that they were currently smoking. Among current smokers, 94.5% ($n = 25,473$) used cigarettes only, while 3.4% ($n = 917$) were dual users.

Regarding sleep duration, physical activity and depressive symptoms, half the participants ($n = 81,079$) reported less than 7 h of sleep per day. A total of 65,814 (35.4%) participants were physically inactive, and 5087 (2.9%) reported moderate-to-severe depressive symptoms.

3.2 | Smoking-related history of current smokers

Regarding smoking-related history (Table 2), most current smokers regardless of smoking type began smoking after age of greater than 19. All e-cigarette users had attempted to quit smoking. Whereas less than a half of cigarette-only smokers had attempted to quit (41.7%, $n = 9995$), 58.8% of dual users ($n = 532$) had attempted to quit.

3.3 | Differences in participants' characteristics by smoking status

Table 3 shows the comparison of participants' general characteristics by smoking status (non-smokers vs. single vs. dual users). Compared with non-smokers and single users, a higher proportion of dual smokers were in the younger age group (40–64 years), men, college level educated or above, had a job and higher income, and lived in urban areas. Further, the proportion of obesity was higher in dual

TABLE 1 Participant characteristics.

Characteristics	Categories	Total (n = 167,809) n (weighted %)
Age (years)	40–64	99,007 (71.7)
	≥65	68,802 (28.3)
Sex	Male	74,400 (48.6)
	Female	93,409 (51.4)
Spouse	No	43,584 (22.5)
	Yes	124,225 (77.5)
Education	Below middle school	74,493 (29.2)
	Completed high school	52,709 (35.5)
	College or higher	40,607 (35.3)
Job	No	28,163 (14.7)
	Yes	139,646 (85.3)
Monthly family Income (10,000 Korean won)	<200	75,087 (31.2)
	200–299	26,535 (16.0)
	300–399	17,867 (12.9)
	≥400	48,320 (39.9)
Residence type	Urban	87,007 (79.3)
	Rural	80,802 (20.7)
Alcohol consumption	No	68,589 (33.1)
	Yes	99,220 (66.9)
BMI (kg/m^2)	Underweight (<18.5)	5424 (2.9)
	Normal (18.5–22.9)	58,788 (35.5)
	Overweight (23–24.9)	42,448 (25.6)
	Obesity (≥25)	61,149 (36.0)
Hypertension	No	107,983 (70.2)
	Yes	59,826 (29.8)
Diabetes	No	143,607 (87.7)
	Yes	24,202 (12.3)
Sleep duration (hours per day)	<7	81,079 (50.0)
	7–8	80,802 (47.2)
	≥9	5928 (2.8)
Physical activity (MET-min/week)	Inactive	65,814 (35.4)
	Minimally active	65,908 (44.1)
	HEPA	36,087 (20.5)
Depressive symptoms by PHQ-9 (Score)	Minimal (0–4)	143,607 (85.9)
	Mild (5–9)	19,115 (11.2)
	Moderate to severe (10–27)	5087 (2.9)

Abbreviations: BMI, body mass index; HEPA, health-enhancing physical activity; MET, metabolic equivalent; PHQ-9, Patient Health Questionnaire-9.

users. The proportion of participants with hypertension was higher in non-smokers than in single or dual users, while the proportion of participants with diabetes was higher in single users.

3.4 | Sleep duration, physical activity and depressive symptoms by smoking status

As shown in Table 3, a higher proportion of dual users reported sleeping less than 7 h per day compared to single users or non-smokers (p = 0.001). Regarding physical activity, cigarette-only smokers were more physically inactive than dual users, whereas dual users were more physically active (HEPA) than single users or non-smokers (p < 0.001). Further, a higher proportion of dual users were mildly, and moderately to severely depressed (p = 0.017).

In Table 4, dual users were more likely to have sleep duration of less than 7 h, compared to cigarette and e-cigarette-only users (p = 0.007). Cigarette-only users were more likely to be physically inactive compared to e-cigarette-only and dual users (p < 0.001). E-cigarette-only and dual users were also more likely to have moderate-to-severe depressive symptoms, compared to cigarette only users (p = 0.024).

3.5 | Multinomial logistic regression results of current smoking status.

In the adjusted model of single (cigarettes only smokers or e-cigarettes only smokers) and dual users (Table 5), dual users of cigarettes and e-cigarettes were more likely to have sleep duration of less than 7 h per day than non-smokers (OR = 1.31, 95% CI = 1.11–1.54, p = 0.001). They were also more likely to report both mild and moderate-to-severe depressive symptoms than non-smokers (OR = 2.36, 95% CI = 1.87–2.98, p < 0.001; OR = 3.86, 95% CI = 2.65–5.63, p < 0.001, respectively). However, there were no significant differences in the likelihood of being in physical activity categories between dual users and non-smokers. In single users, the likelihood of sleeping less than seven or more than 9 h per day was significantly higher than in non-smokers (OR = 1.08, 95% CI = 1.03–1.12, p < 0.001; OR = 1.19, 95% CI = 1.06–1.33, p=,003, respectively). Single users were also more likely to report both mild and moderate-to-severe depressive symptoms than non-smokers (OR = 1.48, 95% CI = 1.38–1.58, p < 0.001; OR = 1.76, 95% CI = 1.56–2.00, p < 0.001, respectively). Regarding physical activity, single users were more likely to be inactive (OR = 1.31, 95% CI = 1.24–1.38, p < 0.001) and less likely to be minimally active (OR = 0.90, 95% CI = 0.85–0.95, p < 0.001) than non-smokers.

4 | DISCUSSION

Despite growing knowledge and awareness to adverse health effects of cigarettes, smoking is still one of the most difficult health risk behaviours to correct. Moreover, since the advent of e-cigarettes, it has become more complicated to identify the trend of smoking or smoking cessation and its effects on lifestyles and health outcomes. In this secondary analysis of a large epidemiological data of 179,004 adults older than 40 years, we identified the associations between

TABLE 2 Comparison of the smoking history of participants who were current smokers.

		Current smokers (n = 26,682)				
		Single users				
Characteristics	Categories	Cigarette only smokers (n = 25,473) n (weighted %)	E-cigarette only smokers (n = 292) n (weighted %)	Dual users (n = 917) n (weighted %)	Rao–Scott χ^2	p-Value
Age when starting smoking (years)	<19	6665 (26.1)	95 (32.5)	292 (31.1)	8.08	<0.001
	≥19	18,808 (73.9)	197 (67.5)	625 (68.9)		
Daily smoking	Light smoker (1–9)	4679 (18.2)	–	162 (18.9)	0.34	0.709
	Medium smoker (10–19)	9484 (40.7)	–	354 (39.1)		
	Heavy smoker (≥20)	11,310 (41.1)	–	401 (42.0)		
Attempts for quit smoking	No	15,478 (58.3)	–	385 (41.2)	169.93	<0.001
	Yes	9995 (41.7)	292 (100.0)	532 (58.8)		

smoking and altered sleep duration and depressive symptoms in both single users (i.e. cigarette or e-cigarette) and dual users. Our findings add insights to understand the prevalence of smoking types among smokers older than 40 years, the age group takes up most of the population in South Korea. Our data also suggest the potential role of smoking, especially dual use of cigarette and e-cigarette, in explaining sleep and depressive symptoms, important determinants of function and long-term health outcomes.

In our findings, 15.9% of middle-aged and older adults in Korea currently smoke (male, 14.4%; female, 1.5%). Although our sample did not include young adults and comparison must be made cautiously, the prevalence of current smoking in this study was considerably lower than the rate reported in the past years. According to the national survey in 2016, during 2008–2013, the prevalence of smoking in male and female adults (≥19 years) was 35.7% and 6.7%, respectively. This progress may be associated with the Korean National Health Promotion Act of 1995, which has been actively pursued in various tobacco control policies, such as school-based smoking prevention education, anti-smoking mass media campaigns, smoke-free policies in many public areas, comprehensive advertising bans, and pictorial health warnings to be printed on tobacco products and increases in the price of tobacco products (Chang et al., 2019). Despite the trend of decreasing smoking prevalence, the characteristics of dual users highlight public health concerns. A higher proportion of dual users was in the middle-aged group. Furthermore, dual use was associated with higher odds of worse health behaviour and poor mental health. Both suggest a worse outlook on long-term physical and mental health when these dual users become older.

Our main findings revealed that both single and dual use of tobacco cigarettes and e-cigarettes were associated with less than 7 h of sleep compared with non-smokers. In single users, likelihood of having longer sleep duration (>9 h per day) was also significantly higher compared with non-smokers. While studies have reported both short sleep duration and long sleep duration are linked to poor health (Kim et al., 2013; Štefan et al., 2017; Yin et al., 2017), reports on shorter sleep duration predominate in studies on sleep and smoking. According to previous studies, smokers reported less total sleep time, lower sleep efficiency and longer sleep latency (Bae et al., 2018; Patterson et al., 2019). Smoking is associated with a variety of sleep disorders, such as obstructive sleep apnea (Boakye et al., 2018) and insomnia (Nunez et al., 2021). According to a study by Nunez et al. (2021) that examined associations between smoking characteristics and sleep, the prevalence of moderate-to-severe insomnia was two-and-a-half times higher than in non-smokers. In the moderate-to-severe insomnia group, nighttime smoking was associated with a higher likelihood of short sleep duration. In another study of 9893 Korean adults, participants in a shorter sleep group (<7 h per day) smoked more cigarettes and identified themselves as heavy smokers compared with the normal sleep group (Yu et al., 2018). In heavy smokers, a disturbed sleep–wake cycle has been explained as a symptom of nightly nicotine withdrawal, an addictive stimulant in cigarettes (Patterson et al., 2019). Assuming a lower nicotine concentration in e-cigarettes, we speculate that nicotine exposure may be higher in heavy cigarette-only smokers than in dual users. In our results, while a vast majority of the sample were cigarette-only smokers, the odds of having shorter sleep duration were higher in dual users. Regarding the association between smoking and longer sleep duration, relatively little attention has been paid. According to one study identified that involved analysis of near 500,000 UK biobank sample data, both shorter and longer sleep duration were highlighted as problems in both former and current smokers compared to never smokers (Boakye et al., 2018). Since sleep disturbance is a multifactorial condition, the mechanisms of sleep duration by smoking types may need further exploration. Lacking objective measures of nicotine concentration and sleep quantity, our data are insufficient to discuss the potential contribution of nicotine dose to sleep quantity between dual and single users. Future studies are warranted to identify the effects of dual use on sleep health using objective measures of nicotine dependence, nighttime smoking and sleep.

Our results showed that both single and dual use of tobacco cigarettes and e-cigarettes are associated with mild and moderate-to-severe depressive symptoms compared with non-smokers.

TABLE 3 Comparison of participants' characteristics, sleep duration, physical activity and depression among non-smokers, single and dual tobacco/e-cigarette users.

			Current smokers (n = 26,682)			
		Non-smokers (n = 141,127)	Single users (n = 25,765)	Dual users (n = 917)		
Characteristics	Categories	n (weighted %)	n (weighted %)	n (weighted %)	Rao–Scott χ^2	p-Value
Age (years)	40–64	78,404 (68.5)	19,720 (85.2)	883 (97.7)	1361.49	<0.001
	≥65	62,723 (31.5)	6045 (14.8)	34 (2.3)		
Sex	Male	50,241 (38.9)	23,304 (91.7)	855 (94.4)	8079.97	<0.001
	Female	90,886 (61.1)	2461 (8.3)	62 (5.6)		
Spouse	No	36,382 (21.9)	6969 (25.4)	233 (22.6)	41.94	<0.001
	Yes	104,745 (78.1)	18,796 (74.6)	684 (77.4)		
Education	Below middle school	66,845 (31.6)	7568 (19.4)	80 (6.8)	299.35	<0.001
	Completed high school	41,464 (33.8)	10,893 (43.5)	352 (35.1)		
	College and higher	32,818 (34.6)	7304 (37.1)	485 (58.1)		
Job	No	23,443 (14.6)	4672 (15.5)	48 (5.1)	30.45	<0.001
	Yes	117,684 (85.4)	21,093 (84.5)	869 (94.9)		
Monthly family Income (10,000 Korean won)	<200	65,457 (32.4)	9478 (26.4)	152 (14.2)	62.53	<0.001
	200–299	21,629 (15.6)	4750 (17.9)	156 (15.0)		
	300–399	14,441 (12.4)	3286 (14.8)	140 (13.1)		
	≥400	39,600 (39.6)	8251 (40.9)	469 (57.7)		
Residence type	Urban	72,686 (79.4)	13,678 (78.2)	643 (85.2)	18.01	<0.001
	Rural	68,441 (20.6)	12,087 (21.8)	274 (14.8)		
Alcohol consumption	No	63,155 (37.0)	5331 (16.1)	103 (10.6)	1167.08	<0.001
	Yes	77,972 (63.0)	20,434 (83.9)	814 (89.4)		
BMI (kg/m^2)	Underweight (<18.5)	4354 (2.8)	1055 (3.4)	15 (1.4)	18.28	<0.001
	Normal (18.5–22.9)	49,309 (36.0)	9260 (33.9)	219 (23.5)		
	Overweight (23–24.9)	35,722 (25.6)	6511 (25.9)	215 (23.0)		
	Obesity (≥25)	51,742 (35.6)	8939 (36.8)	468 (52.1)		
Hypertension	No	88,538 (69.0)	18,725 (72.7)	720 (78.9)	6.89	0.001
	Yes	52,589 (31.0)	7040 (27.3)	197 (21.1)		
Diabetes	No	120,669 (87.7)	22,135 (85.9)	803 (87.4)	3.21	0.041
	Yes	20,458 (12.3)	3630 (14.1)	114 (12.6)		
Sleep duration (hours per day)	<7	68,268 (49.9)	12,323 (50.4)	488 (56.0)	4.62	0.001
	7–8	67,852 (47.3)	12,541 (46.9)	409 (42.8)		
	≥9	5007 (2.8)	901 (2.7)	20 (1.2)		
Physical activity (MET-min/week)	Inactive	55,710 (35.2)	9804 (36.4)	300 (31.3)	84.33	<0.001
	Minimally active	56,548 (45.4)	9003 (38.3)	357 (40.9)		
	HEPA	28,869 (19.4)	6958 (25.3)	260 (27.8)		
Depressive symptoms by PHQ-9 (Score)	Minimal (0–4)	120,581 (86.0)	22,269 (85.9)	757 (81.8)	3.03	0.017
	Mild (5–9)	16,300 (11.1)	2691 (11.1)	124 (14.1)		
	Moderate to severe (10–27)	4246 (2.9)	805 (3.0)	36 (4.1)		

Abbreviations: BMI, body mass index; HEPA, health-enhancing physical activity; MET, metabolic equivalent; PHQ-9, Patient Health Questionnaire-9.

Importantly, the risk of moderate-to-severe depressive symptoms in dual smokers is much higher than in single users. This finding was in line with previous studies, showing that current smokers had a significantly higher risk of depressive symptoms than those who had never smoked (Moon et al., 2019; Schlyter et al., 2016). One study reported that dual users exhibited higher depressive symptoms compared to cigarette-only users (Kang & Bae, 2021). Another study found that about 40% of adults with depressive symptoms were current smokers, compared with those who were not depressed; further, individuals with depressive symptoms were more than twice as likely to be

TABLE 4 Comparison of characteristics, sleep duration, physical activity and depression between single- and dual-user participants.

		Current smokers (n = 26,682)				
		Single users				
Characteristics	Categories	Cigarette only smokers (n = 25,473) n (weighted %)	E-cigarette only smokers (n = 292) n (weighted %)	Dual users (n = 917) n (weighted %)	Rao–Scott χ^2	p-Value
Age (years)	40–64	19,445 (85.0)	275 (96.4)	883 (97.7)	900.37	<0.001
	≥65	6028 (15.0)	17 (3.6)	34 (2.3)		
Sex	Male	23,030 (91.7)	274 (95.1)	855 (94.4)	5008.78	<0.001
	Female	2443 (8.3)	18 (4.9)	62 (5.6)		
Spouse	No	6922 (25.6)	47 (16.3)	233 (22.6)	29.29	<0.001
	Yes	18,551 (74.4)	245 (83.7)	684 (77.4)		
Education	Below middle school	7551 (19.7)	17 (3.6)	80 (6.8)	215.24	<0.001
	Completed high school	10,799 (43.8)	94 (26.9)	352 (35.1)		
	College or higher	7123 (36.5)	181 (69.5)	485 (58.1)		
Job	No	4652 (15.7)	20 (6.5)	48 (5.1)	25.08	<0.001
	Yes	20,821 (84.3)	272 (93.5)	869 (94.9)		
Monthly family Income (10,000 Korean won)	<200	9442 (26.7)	36 (8.3)	152 (14.2)	46.52	<0.001
	200–299	4701 (17.9)	49 (15.1)	156 (15.0)		
	300–399	3254 (14.9)	32 (12.0)	140 (13.1)		
	≥400	8076 (40.5)	175 (64.6)	469 (57.7)		
Residence type	Urban	13,456 (78.1)	222 (87.2)	643 (85.2)	15.75	<0.001
	Rural	12,017 (21.9)	70 (12.8)	274 (14.8)		
Alcohol consumption	No	5291 (16.1)	40 (11.4)	103 (10.6)	810.29	<0.001
	Yes	20,182 (83.9)	252 (88.6)	814 (89.4)		
BMI (kg/m^2)	Underweight (<18.5)	1049 (3.4)	6 (1.9)	15 (1.4)	13.48	<0.001
	Normal (18.5–22.9)	9181 (34.0)	79 (28.7)	219 (23.5)		
	Overweight (23–24.9)	6450 (26.0)	61 (23.0)	215 (23.0)		
	Obesity (≥25)	8793 (36.6)	146 (46.4)	468 (52.1)		
Hypertension	No	18,491 (75.2)	234 (84.2)	720 (78.9)	84.02	<0.001
	Yes	6982 (24.8)	58 (15.8)	197 (21.1)		
Diabetes	No	21,869 (87.6)	266 (93.2)	803 (87.4)	2.32	0.074
	Yes	3604 (12.4)	26 (6.8)	114 (12.6)		
Sleep duration (hours per day)	<7	12,169 (50.4)	154 (51.6)	488 (56.0)	3.07	0.007
	7–8	12,405 (46.9)	136 (47.4)	409 (42.8)		
	≥9	899 (2.7)	2 (1.0)	20 (1.2)		
Physical activity (MET-min/week)	Inactive	9702 (36.5)	102 (30.3)	300 (31.3)	54.87	<0.001
	Minimally active	8878 (38.2)	125 (46.5)	357 (40.9)		
	HEPA	6893 (25.3)	65 (23.2)	260 (27.8)		
Depressive symptoms by PHQ-9 (Score)	Minimal (0–4)	22,010 (85.9)	259 (87.2)	757 (81.8)	2.50	0.024
	Mild (5–9)	2668 (11.1)	23 (8.0)	124 (14.1)		
	Moderate to severe (10–27)	795 (3.0)	10 (4.8)	36 (4.1)		

Abbreviations: BMI, body mass index; HEPA, health-enhancing physical activity; MET, metabolic equivalent; PHQ-9, Patient Health Questionnaire-9.

current smokers (Goodwin et al., 2017). Depressive symptoms are a barrier to the success of smoking cessation interventions (Quinn et al., 2022). In our sample, approximately one-fourth of current smokers started smoking by the age of 19. Nicotine is known to affect many other neurotransmitters in the central nervous system (CNS), such as serotonin. (Bombardi et al., 2020). Chronic nicotine

TABLE 5 Results of multinomial logistic regression of current smoking status.

	Current smokers[a]							
	Single users				Dual users			
Outcome variables	Unadjusted OR (95% CI)	*p*-Value	Adjusted OR (95% CI)	*p*-Value	Unadjusted OR (95% CI)	*p*-Value	Adjusted OR (95% CI)	*p*-Value
Sleep duration (per day)								
7–8 h	1.00		1.00		1.00		1.00	
<7 h	1.02 (0.99–1.06)	0.253	1.08 (1.03–1.12)	<0.001	1.24 (1.06–1.46)	0.009	1.31 (1.11–1.54)	0.001
≥9 h	0.98 (0.89–1.08)	0.675	1.19 (1.06–1.33)	0.003	0.47 (0.27–0.82)	0.008	0.85 (0.49–1.49)	0.578
Physical activity (MET-min/week)								
HEPA	1.00		1.00		1.00		1.00	
Minimally active	0.65 (0.62–0.68)	<0.001	0.90 (0.85–0.95)	<0.001	0.63 (0.52–0.77)	<0.001	0.86 (0.70–1.05)	0.129
Inactive	0.80 (0.76–0.83)	<0.001	1.31 (1.24–1.38)	<0.001	0.62 (0.51–0.76)	<0.001	1.14 (0.93–1.41)	0.207
Depressive symptoms								
Minimal	1.00		1.00		1.00		1.00	
Mild	0.99 (0.94–1.05)	0.836	1.48 (1.38–1.58)	<0.001	1.33 (1.06–1.68)	0.015	2.36 (1.87–2.98)	<0.001
Moderate to severe	1.05 (0.95–1.16)	0.329	1.76 (1.56–2.00)	<0.001	1.50 (1.06–2.14)	0.023	3.86 (2.65–5.63)	<0.001

Note: Adjusted for age, sex, spouse, education, job, monthly family income, residency, alcohol intake, hypertension and diabetes.

Abbreviations: MET, metabolic equivalent; HEPA, health-enhancing physical activity; PHQ-9, Patient Health Questionnaire-9.

aReference group = non-smokers.

exposure might reduce serotonin levels, thus influencing depressive symptoms (Simonnet et al., 2017). According to the serotonin theory of depression, impairing serotonin function can influence mood in a way that leads to clinical depression (O'Gara et al., 2008). Therefore, assessment of depressive symptoms among current smokers can help prevent addictive smoking behaviours or symptoms of nicotine withdrawal. However, the data used in this study did not contain details on history of smoking cessation, use of antidepressants, or past mental health history. Longitudinal studies are necessary to identify the causal relationship between dual use and depressive symptoms.

We found that dual use was not associated with the odds of physical inactivity, while the odds were significant for single users. The association between physical activity and smoking is not fully understood. Previous studies have reported problems of reduced physical activity and poor physical endurance in smokers (Jackson et al., 2019; Zabaleta-Del-Olmo et al., 2021). By contrast, some studies showed no significant relationship between smoking and physical activity, explaining that smokers may have used physical activity as a weight control strategy or as a harm reduction strategy regarding smoking (Jackson et al., 2019; Zabaleta-Del-Olmo et al., 2021). This inconsistency is attributed to the varying definitions applied to classify smoking status and physical activity levels (Fazelipour & Cunningham, 2019).

Nurses can participate in promoting tobacco control efforts through multiple channels, which include participating in professional education to enhance knowledge of tobacco treatment, enhancing public education materials, supporting local, state and national legislative and regulatory efforts related to tobacco control, and furthering nursing research on tobacco prevention and cessation interventions. Moreover, hospital nurses are usually in close contact with inpatients and spend a lot of time with them; thus, this provides a chance to educate patients with current smoking to improve their health in relation to smoking cessation. Hospital nurses as well as community nurses should ensure identification and documentation of the *smoking* status of all admitted *patients to prevent adverse patient outcomes*.

4.1 | Limitations

The present study had several limitations. First, our analysis is based on cross-sectional survey data, which limits the identification of causal relationships between the variables. Second, the proportion of e-cigarette-only users was too small to analyse independent comparisons with other single or dual users or non-smokers. Additionally, among current smokers, information on the length and pattern of smoking cessation efforts is lacking. For future studies, evaluating smoking status needs more sophistication, such as including assessment of former smokers and never smokers. Third, data were self-reported and lacked objective measures (e.g. nicotine levels, sleep duration and physical activity). Although self-reported sleep duration is widely used because of its ease of use, the correlation between self-reported and actigraphy-measured sleep duration has not been strong (Jackson et al., 2020). Accordingly, comprehensive assessment tools for sleep duration are required.

5 | CONCLUSIONS

Our findings highlight that dual use of tobacco cigarettes and e-cigarettes may have greater risk of shorter sleep duration and depressive symptoms compared to single users and non-smokers. Therefore, nurses, as the largest group of healthcare professionals, need to be knowledgeable about the smoking-related health issues in both single users and dual users; future smoking cessation interventions should be tailored to smoking types. Hospital nurses may have relatively less opportunity to educate the importance of smoking cessation compared to nurses working in the community health settings (Halcomb et al., 2015). However, smoking cessation counselling before hospital discharge may be vital to prevent smoking-related health conditions or aggravation of pre-existing illnesses. Thus, hospital nurses also need up-to-date understanding on health-related concerns associated with dual cigarette smoking. Furthermore, early assessment of depressive symptoms and timely psychosocial mood management may be beneficial to successful smoking cessation plan for current smokers. Longitudinal studies are needed to unravel the complex relationship between the direct effects of dual use of cigarettes and e-cigarettes, psycho-behavioural factors that may link smoking habits and age/gender differences.

AUTHOR CONTRIBUTIONS

Study design, data collection, data analysis, manuscript writing and critical revisions for important intellectual content were made by MAY, JYC and YJS.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest have been declared.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created in this study.

RESEARCH ETHICS COMMITTEE APPROVAL

The study protocol was approved by the Institutional Review Board (IRB) of Chung-Ang University (IRB No. 1041078-202, 108-HRSB-248-01)

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