1 | INTRODUCTION

The World Health Organization (WHO) cites tobacco-related death and illness as drivers of poverty, as they force individuals to bear high medical expenses.[1] Furthermore, tobacco contains over 7000 toxic chemicals including several known to be human carcinogens.[1] Given this, tobacco smoking is associated with numerous preventable chronic diseases. In addition to the well-known tobacco-related lung cancer, smoking is also a key risk factor for oral cancer, esophageal cancer, larynx cancer, and pancreatic cancer.[2,3] Stopping tobacco use is often said to be the most important element of cancer prevention in the world today.[4] Although smoking has decreased in some countries, there are still ≈120 million smokers globally.[5] The prevalence of smoking in South Korea is among the highest in the world. In 2016, ≈40.7% of men and 6.4% of women over the age of 19 were smokers in Korea.[6] Therefore, government and public health professionals have made intensive efforts to reduce tobacco use by implementation of strong and effective tobacco control polices and measures, such as tobacco tax increases, media campaigns.[7]

As social interest in quitting smoking has increased, interest in electronic cigarettes has increased.[8] Electronic cigarettes are battery-operated devices that are designed to vaporize a mixture of nicotine and other chemicals, which heat the vapor via a battery.[9] Recently electronic cigarettes have been commonly used as a smoking cessation aid in South Korea.[10] Some advertisements describe electronic cigarettes as a healthier alternative to conventional cigarettes.[7] As this perception of electronic cigarettes has become widespread throughout the culture, the number of electronic cigarette vapers has been growing rapidly.[11,12] One prior study suggested that people choose electronic cigarettes as a smoking substitute; however, the risk of developing smoking-related diseases, particularly periodontal diseases, could still be high, as there is a lack of research about the safety of electronic cigarettes.[13] Thus, this phenomenon should be urgently examined.

Periodontal disease is a chronic inflammatory condition characterized by destruction of the periodontal tissues,[14] resulting in loss of connective tissue attachment, loss of alveolar bone,[15] and the formation of pathological pockets around the diseased teeth.[14] According to the 2013–2015 Korean National Health and Nutrition Examination Survey (KNHANES), 31.5% of people have periodontal disease (51.8% men; 48.2% women).[16] Furthermore, oral diseases in adult life are linked to other systemic illnesses, making it important to manage oral diseases, as doing so can prevent stroke, cancer, heart disease, obesity, and diabetes.[17]

Smoking is the single most important environmental factor associated with non-inflammatory diseases of the oral cavity, as well as being an important cause of periodontitis, which is a limiting factor in dental health.[18] Not only smoking, vaping could influence on periodontal health. Some previous study shows that direct exposure to electronic liquids has also been shown to produce harmful effects in periodontal ligament cells.[19] Reactive aldehydes derived from electronic cigarette aerosol can cause protein carbonylation which may lead to destruction of matrix and bone loss during periodontitis.[20,21] But still, the use of electronic cigarettes has increased for various reasons, including the perception that it is less harmful than conventional cigarette smoking and that it can be used as a means to quit smoking.[8] Therefore, it is necessary to investigate the possible association between electronic cigarette and periodontal diseases and provide evidences that could support determining whether or not vaping is safer than smoking. To the authors' knowledge, there is no clinical study that shows the association of conventional cigarette smoking and electronic cigarette vaping with periodontal diseases using community periodontal index (CPI) score. The hypothesis of this study is that vaping has significant relation to periodontal disease just as much as smoking does.

Consequently, the current study sought to examine the association of electronic cigarette and conventional cigarettes individually with periodontal disease among South Korean adults.

2 | METHODS

2.1 | Participants

Data for this study was taken from a sample of the 2013–2015 KNHANES, an investigation into the health of the public, the status of chronic diseases, and the status of food/nutrition. The survey was conducted by the Korea Centers for Disease Control and Prevention (KCDC).

The total number of participants for the 2013–2015 KNHANES was 29,321. Information from individuals aged 1 to 18 years was excluded because KNHANES did not ask persons aged under 19 years about cigarettes. Furthermore, data were excluded from four individuals who were unable to provide information about smoking or vaping cigarette. We also excluded those who were unable to provide information about age, education, marriage, region, income, alcohol status, occupation, the number of days walking per week, subjective health status, subjective stress level, subjective oral health status, dental caries, toothache within past year, or the experience of dental damage. Following all exclusions, a total of 13,551 participants (men: 5,715 and women: 7,836) were analyzed.

2.2 | Variables

Participants were classified into four groups: electronic cigarette users, conventional cigarette users, ex-users, and

non-users. Individuals who answered "Yes" to the questions about electronic cigarettes were placed in the electronic cigarette group. Individuals who reported "Yes" to the conventional cigarette question, were placed in the conventional cigarette group. Ex-users and non-users were determined by a "Yes" answer to a direct question (i.e., "Are you a former cigarette user?"). Additionally, analyses included demographic, socioeconomic, and health-related characteristics. The demographic analysis consisted of age, gender, and marital status. The socioeconomic analysis consisted of education, region, household income level, and occupation. The health-related characteristics analyzed were alcohol status, number of walking days in a week, self-reported health status, and stress level. Dental related variables, such as self-reported oral health status, dental caries, toothache within the past year, and the experience of dental damage were also included.

Periodontal disease was the main dependent variable in this study. Periodontal status was divided into 0 to 4 points, using the CPI, which was recommended by the WHO.[22] A CPI score of 0 represents healthy periodontal tissue, 1 means bleeding periodontal tissue, 2 means periodontal tissue with plaques, 3 means periodontal tissue with shallow periodontal pockets ($3.5 \leq$ pocket depth < 5.5 mm), and 4 means periodontal tissue with deep periodontal pockets (pocket depth ≥ 5.5 mm).[23] In this study, a score of 3 to 4 was considered to denote periodontal disease.[24]

2.3 | Statistical analysis

A chi-square test was conducted to investigate the general characteristics of the study population. Multiple logistic regression analysis was performed to examine the association of conventional cigarette smoking and electronic cigarette vaping with periodontal disease, after accounting for potential confounding variables including demographic, socio-economic, and health-related characteristics. Results are reported as odds ratio (OR) and confidence interval (CI). Subgroup analyses were also performed with multiple logistic regression stratified by gender, to investigate the associations with self-reported oral health status, education level, region, dental caries, toothache within the past year, and the experience of dental damage. The analysis used a stratified sampling variable (kstrata), clustering variable (primary sampling units) provided by KNHANES. All analyses included the use of weighted variables. Differences were considered statistically significant with a P value < 0.05. All data analyses used SAS 9.4 software.

3 | RESULTS

Table 1 presents the general characteristics of the study population. Included is the presence or absence of periodontal disease according to sex. Among the participants (5,715 men and 7,836 women), 2,206 men (38.6%) and 2,054 women (26.2%) exhibited periodontal disease. The relationship between vaping or smoking each cigarette and periodontal disease was statistically significant. Additionally, differences in demographic, socio-economic, and health-related characteristics were also generally significant.

Table 2 shows the association of cigarette smoking and electronic cigarette vaping with periodontal disease. Compared to people who never used cigarettes, people who use electronic or conventional cigarettes demonstrated a higher risk of periodontal diseases. These results were especially evident in men (men, electronic cigarette: OR = 2.41, 95% CI = 1.57 to 3.72, conventional cigarette: OR = 2.22, 95% CI = 1.80 to 2.73). As age increased, both men and women demonstrated an increased risk of periodontal disease. This was generally significant, but not statistically significant from the age of 50 and older. People living in urban areas were less likely to suffer periodontal disease than people living in rural areas. Dental related variables were also related to periodontal disease. In self-reported oral health status, people who reported high levels of oral health demonstrated a lower risk of periodontal disease. Furthermore, when individuals reported dental caries or toothache, more periodontal disease was noted for both sexes. These results were significant for both men and women. Finally, while individuals who reported dental damage also exhibited more instances of periodontal disease, the difference did not reach statistical significance.

Table 3 shows results of subgroup analyses between cigarette usage and periodontal disease, focusing on self-reported oral health status, education level, region, dental caries, toothache within the past year, and the experience of dental damage. For self-reported oral health status, electronic cigarette vapers or conventional cigarettes smokers demonstrated a higher likelihood of having periodontal disease than those who never used. Furthermore, the risk of periodontal disease in cigarette users increased even in individuals who self-reported high levels of oral health. In other words, self-reported oral health status did not have a large effect in predicting periodontal disease. Other dental diseases, such as dental caries, toothache, and dental damage, were associated with an increased likelihood of periodontal disease in electronic cigarette vapers or conventional cigarette smoker. However, the risk was also high for those who vaping or smoking cigarette who did not report dental caries, toothache, and/or dental damage. Vapers and smokers were also more likely to have periodontal disease, regardless of whether they lived in an urban or rural area, when compared to individuals who never use cigarettes. Finally, vaping or smoking individuals were more likely to suffer from periodontal disease, regardless of education level, when compared to non-users.

TABLE 1 General characteristics of study population

Variables	Total (N = 13,551)			Male (n = 5,715)					Female (n = 7,836)				
				Periodontal disease					Periodontal disease				
				Yes		No			Yes		No		
	n	(%)		*n*	(%)	*n*	(%)	*P* value	*n*	(%)	*n*	(%)	*P* value
Cigarette usage			<0.0001					<0.0001					0.0019
Electronic cigarette	222	(1.6)		67	(35.8)	120	(64.2)		10	(28.6)	25	(71.4)	
Conventional cigarette	2,320	(17.1)		861	(44.0)	1,096	(56.0)		121	(33.3)	242	(66.7)	
Ex-use	2,667	(19.7)		946	(41.9)	1,311	(58.1)		87	(21.2)	323	(78.8)	
Non-use	8,342	(61.6)		332	(25.3)	982	(74.7)		1,836	(26.1)	5,192	(73.9)	
Age (years)			<0.0001					<0.0001					<0.0001
19–29	1,753	(12.9)		37	(4.7)	749	(95.3)		35	(3.6)	932	(96.4)	
30–39	2,293	(16.9)		172	(18.4)	761	(81.6)		163	(12.0)	1,197	(88.0)	
40–49	2,520	(18.6)		404	(38.4)	647	(61.6)		313	(21.3)	1,156	(78.7)	
50–59	2,722	(20.1)		614	(55.3)	497	(44.7)		537	(33.3)	1,074	(66.7)	
≥60	4,263	(31.5)		979	(53.4)	855	(46.6)		1,006	(41.4)	1,423	(58.6)	
Educational level			<0.0001					<0.0001					<0.0001
Middle school or less	4,097	(30.2)		738	(55.8)	584	(44.2)		1,135	(40.9)	1,640	(59.1)	
High school	3,876	(28.6)		778	(46.1)	911	(53.9)		543	(24.8)	1,644	(75.2)	
College and beyond	5,578	(41.2)		690	(25.5)	2,014	(74.5)		376	(13.1)	2,498	(86.9)	
Marital Status			<0.0001					<0.0001					<0.0001
Married	9,604	(70.9)		1,876	(44.2)	2,365	(55.8)		1,440	(26.9)	3,923	(73.1)	
Separated or divorced	1,754	(12.9)		188	(54.5)	157	(45.5)		557	(39.5)	852	(60.5)	
Unmarried	2,193	(16.2)		142	(12.6)	987	(87.4)		57	(5.4)	1,007	(94.6)	
Region			<0.0001					<0.0001					<0.0001
Urban	6,350	(46.9)		912	(34.9)	1,702	(65.1)		823	(22.0)	2,913	(78.0)	
Rural	7,201	(53.1)		1,294	(41.7)	1,807	(58.3)		1,231	(30.0)	2,869	(70.0)	
Household income level		<0.0001						<0.0001					<0.0001
Low	2,412	(17.8)		453	(49.0)	471	(51.0)		582	(39.1)	906	(60.9)	
Lower middle	3,449	(25.5)		582	(40.7)	848	(59.3)		578	(28.6)	1,441	(71.4)	
Upper middle	3,755	(27.7)		585	(36.2)	1,033	(63.8)		464	(21.7)	1,673	(78.3)	
High	3,935	(29.0)		586	(33.6)	1,157	(66.4)		430	(19.6)	1,762	(80.4)	
Alcohol status			<0.0001				0.3318						<0.0001
Never	1,635	(12.1)		111	(41.4)	157	(58.6)		513	(37.5)	854	(62.5)	
Ever	11,916	(87.9)		2,095	(38.5)	3,352	(61.5)		1,541	(23.8)	4,928	(76.2)	
Occupational classification			<0.0001					<0.0001					<0.0001
White-collar	3,098	(22.9)		474	(29.7)	1,120	(70.3)		209	(13.9)	1,295	(86.1)	
Blue-collar	3,167	(23.4)		920	(47.2)	1,031	(52.8)		458	(37.7)	758	(62.3)	
Pink-collar	1,734	(12.8)		196	(31.0)	436	(69.0)		299	(27.1)	803	(72.9)	
None	5,552	(41.0)		616	(40.1)	922	(59.9)		1,088	(27.1)	2,926		(72.9)
Number of days walking per week			< 0.0001					< 0.0001					0.0001
None	2,268	(16.7)		434	(46.6)	497	(53.4)		420	(31.4)	917	(68.6)	
1–2	2,386	(17.6)		401	(39.9)	604	(60.1)		359	(26.0)	1,022	(74.0)	
3–4	2,789	(20.6)		422	(39.9)	635	(60.1)		434	(25.1)	1,298	(74.9)	
5–6	2,292	(16.9)		331	(35.1)	611	(64.9)		330	(24.4)	1,020	(75.6)	
Everyday	3,816	(28.2)		618	(34.7)	1,162	(65.3)		511	(25.1)	1,525	(74.9)	

(Continues)

TABLE 1 (Continued)

Variables	Total (N = 13,551)			Male (n = 5,715)					Female (n = 7,836)				
				Periodontal disease					Periodontal disease				
				Yes		No			Yes		No		
	n	(%)		*n*	(%)	*n*	(%)	*P* value	*n*	(%)	*n*	(%)	*P* value
Self-reported health status			<0.0001					<0.0001					<0.0001
High	4,111	(30.3)		640	(32.3)	1,344	(67.7)		447	(21.0)	1,680	(79.0)	
Middle	6,885	(50.8)		1,162	(40.4)	1,713	(59.6)		1,073	(26.8)	2,937	(73.2)	
Low	2,555	(18.9)		404	(47.2)	452	(52.8)		534	(31.4)	1,165	(68.6)	
Stress level			<0.0001					<0.0001					<0.0001
High	3,336	(24.6)		417	(32.4)	869	(67.6)		477	(23.3)	1,573	(76.7)	
Middle	7,901	(58.3)		1,309	(39.0)	2,047	(61.0)		1,170	(25.7)	3,375	(74.3)	
Low	2,314	(17.1)		480	(44.7)	593	(55.3)		407	(32.8)	834	(67.2)	
Self-reported oral health status			<0.0001					<0.0001					<0.0001
High	1,997	(14.7)		258	(28.8)	637	(71.2)		233	(21.1)	869	(78.9)	
Middle	5,595	(41.3)		675	(30.8)	1,517	(69.2)		728	(21.4)	2,675	(78.6)	
Low	5,959	(44.0)		1,273	(48.4)	1,355	(51.6)		1,093	(32.8)	2,238	(67.2)	
Dental caries			<0.0001				0.008						<0.0001
Yes	3,957	(29.2)		785	(41.0)	1,130	(59.0)		620	(30.4)	1,422	(69.6)	
No	9,594	(70.8)		1,421	(37.4)	2,379	(62.6)		1,434	(24.7)	4,360	(75.3)	
Toothache within the past year			<0.0001					<0.0001					<0.0001
Yes	5,262	(38.8)		1,038	(46.3)	1,203	(53.7)		890	(29.5)	2,131	(70.5)	
No	8,289	(61.2)		1,168	(33.6)	2,306	(66.4)		1,164	(24.2)	3,651	(75.8)	
Experienced dental damage			<0.0001					0.0760				0.3572	
Yes	1,626	(12.0)		412	(41.1)	591	(58.9)		173	(27.8)	450	(72.2)	
No	11,925	(88.0)		1,794	(38.1)	2,918	(61.9)		1,881	(26.1)	5,332	(73.9)	
Year			0.0002					0.0935					0.0002
2013	4,836	(35.7)		752	(36.7)	1,295	(63.3)		676	(24.2)	2,113	(75.8)	
2014	4,340	(32.0)		711	(39.9)	1,073	(60.1)		652	(25.5)	1,904	(74.5)	
2015	4,375	(32.3)		743	(39.4)	1,141	(60.6)		726	(29.1)	1,765	(70.9)	
Total	13,551	(100.0)		2,206	(38.6)	3,509	(61.4)		2,054	(26.2)	5,782	(73.8)	

4 | DISCUSSION

The WHO consistently reports on the severity of health issues caused by smoking, and emphasizes the importance of quitting.[1,18] The worsening oral health of cigarette users, represented by increases in various diseases, is especially concerning.[18,25–27] The American Academy of Periodontology has stated that smoking is one of the risk factors that may affect treatment and therapeutic outcomes for periodontal diseases.[28–30] In the current study, data from the 2013–2015 KNHANES yielded association of conventional cigarette smoking and electronic cigarette vaping with periodontal disease, after adjusting for demographic, socioeconomic, and health-related characteristics. This association was higher in both electronic cigarette vapers and conventional cigarette smokers, when compared to non-users. These results indicate that stopping cigarette use provides a substantial benefit to periodontal health.[31]

Smoking leads to an augmentation in oral Gram-negative bacteria, which in turn increases dental calculus and gingivitis.[32] As gingivitis is an initial symptom of periodontal disease, this shows a clear path in how smoking amplifies the risk of periodontal disease. This is true not only for conventional cigarettes, but also electronic cigarettes, as the current results indicate. In a previous study resembling ours, the evidence suggested a correlation between vaping electronic cigarette and increased risk of periodontal damage due to high levels of nicotine dosing.[13] Electronic cigarette is a

TABLE 2 Factors associated with periodontal disease

	Male		Female	
	Periodontal disease		Periodontal disease	
Variables	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**
Cigarette usage				
Electronic cigarette	2.34	(1.52–3.59)	2.27	(0.89–5.80)
Conventional cigarette	2.17	(1.76–2.68)	1.73	(1.32–2.27)
Ex-use	1.28	(1.05–1.56)	1.00	(0.74–1.34)
Non-use	1.00		1.00	
Age (years)				
19–29	0.06	(0.04–0.09)	0.09	(0.06–0.16)
30–39	0.21	(0.15–0.28)	0.28	(0.20–0.39)
40–49	0.58	(0.46–0.74)	0.52	(0.41–0.66)
50–59	1.06	(0.86–1.30)	0.87	(0.73–1.03)
≥60	1.00		1.00	
Educational level				
Middle school or less	1.30	(1.04–1.64)	1.42	(1.09–1.84)
High school	1.37	(1.14–1.64)	1.18	(0.96–1.45)
College and beyond	1.00		1.00	
Marital status				
Married	1.05	(0.78–1.42)	1.52	(1.05–2.20)
Separated or divorced	1.06	(0.71–1.60)	1.55	(1.03–2.32)
Unmarried	1.00		1.00	
Region				
Urban	0.74	(0.62–0.89)	0.70	(0.59–0.84)
Rural	1.00		1.00	
Household income level				
Low	1.06	(0.81–1.39)	1.45	(1.15–1.83)
Lower middle	1.05	(0.83–1.32)	1.31	(1.08–1.59)
Upper middle	0.99	(0.81–1.22)	1.06	(0.87–1.28)
High	1.00		1.00	
Alcohol status				
Never	1.05	(0.73–1.50)	1.21	(1.03–1.42)
Ever	1.00		1.00	
Occupational classification				
White-collar	1.09	(0.84–1.42)	1.10	(0.89–1.37)
Blue-collar	1.01	(0.82–1.26)	1.11	(0.92–1.33)
Pink-collar	0.96	(0.73–1.26)	1.17	(0.97–1.41)
None	1.00		1.00	
Number of days walking per week				
None	1.04	(0.83–1.29)	0.99	(0.81–1.20)
1–2	1.12	(0.89–1.40)	1.14	(0.94–1.38)
3–4	1.09	(0.88–1.35)	1.18	(0.98–1.42)
5–6	1.05	(0.83–1.33)	1.08	(0.88–1.32)
Everyday	1.00		1.00	
Self-reported health status				
High	0.89	(0.69–1.15)	1.11	(0.90–1.38)
Middle	0.99	(0.79–1.23)		(0.95–1.33)
Low	1.00		1.00	

(Continues)

TABLE 2 (Continued)

	Male		Female	
	Periodontal disease		Periodontal disease	
Variables	**Adjusted OR**	**95% CI**	**Adjusted OR**	**95% CI**
Stress level				
High	0.65	(0.51–0.83)	0.75	(0.61–0.92)
Middle	0.84	(0.69–1.01)	0.88	(0.74–1.05)
Low	1.00		1.00	
Self-reported oral health status				
High	0.51	(0.41–0.63)	0.58	(0.47–0.71)
Middle	0.60	(0.51–0.70)	0.67	(0.57–0.78)
Low	1.00		1.00	
Dental caries				
Yes	1.26	(1.07–1.48)	1.38	(1.18–1.61)
No	1.00		1.00	
Toothache within the past year				
Yes	1.37	(1.19–1.58)	1.15	(1.01–1.32)
No	1.00		1.00	
Experienced dental damage				
Yes	1.14	(0.95–1.36)	1.02	(0.81–1.27)
No	1.00		1.00	
Year				
2013	0.95	(0.75–1.19)	0.76	(0.60–0.96)
2014	1.05	(0.83–1.33)	0.84	(0.67–1.05)
2015	1.00		1.00	

preferred option for people who attempts quitting; however, electronic cigarette also delivers nicotine. Thus, vaping electronic cigarette could be another way to create new nicotine addicts.[9] These results show that both electronic cigarette vaping and conventional cigarette smoking are risk factors of periodontal diseases.

In both men and women, higher age increased the likelihood of periodontal disease, a result supported by previous research that has shown correlations with age.[33] It is notable that in the current study, incidence of periodontal disease increased with age, but lost statistical significance at age 50. This counterintuitive result is likely due to the loss of teeth that occurs with aging. In other words, individuals with fewer teeth are less likely to exhibit periodontal disease.[18]

For the dental related variables, individuals who reported vaping electronic cigarette or smoking conventional cigarettes demonstrated a higher risk for periodontal disease than non-users. Interestingly, there was little difference in dental caries, toothache, and dental damage between these two groups. This shows that vaping or smoking each cigarettes affects periodontal disease independently of other dental issues.

In the analysis of regional variables, both electronic cigarette vapers and conventional cigarettes smokers demonstrated higher chances of having periodontal disease than non-users. However, this effect was more pronounced in rural areas. This could be due to differences in healthcare accessibility associated with regional characteristics. A prior study reported that rural residents have fewer chances to visit healthcare services and see fewer medical specialists (i.e., more generalists) for their care than urban residents.[34] This means that citizens living in rural areas have less of a chance to see a specialist, resulting in worsening of oral health.

It should be noted that the current study has several limitations. First, the results of this study are based on self-reporting. Thus, some survey questions might be subject to recall bias, especially for health-related characteristics. Responses could also have been affected by social desirability bias. Therefore, caution should be taken when interpreting the results. Second, due to this study's cross-sectional design, cause, effect, and directionality of the relationships observed cannot be determined. Third, only the CPI was used to assess periodontal disease. Assessments might have been inaccurate because the CPI can overestimate the severity of disease[35] and underestimate it in patients with previous periodontal care.[23] Nevertheless, the WHO promotes use of the CPI,[22] since it is useful when dealing with large numbers of participants.[36] Fourth, the duration of smoking and vaping habits and daily

TABLE 3 Subgroup analysis of associations between cigarette usage and periodontal disease stratified by covariates

	Non-use	Electronic cigarette		Conventional cigarette		Ex-use	
	Adjusted OR	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Male							
Self-reported oral health status							
High	1.00	3.84	(1.15–12.75)	1.47	(0.80–2.73)	0.83	(0.48–1.44)
Middle	1.00	1.95	(0.88–4.35)	2.04	(1.42–2.92)	1.22	(0.87–1.70)
Low	1.00	2.49	(1.40–4.42)	2.56	(1.94–3.39)	1.52	(1.14–2.03)
Educational level							
Middle school or less	1.00	2.21	(0.76–6.40)	2.20	(1.41–3.45)	1.14	(0.78–1.66)
High school	1.00	2.05	(0.98–4.27)	2.06	(1.41–2.99)	1.35	(0.94–1.94)
College and beyond	1.00	2.51	(1.35–4.66)	2.39	(1.72–3.31)	1.33	(0.98–1.82)
Region							
Urban	1.00	2.16	(1.04–4.51)	1.96	(1.44–2.68)	1.22	(0.89–1.67)
Rural	1.00	2.64	(1.54–4.51)	2.31	(1.74–3.08)	1.30	(1.01–1.66)
Dental caries							
Yes	1.00	1.99	(0.93–4.26)	2.43	(1.68–3.52)	1.28	(0.89–1.83)
No	1.00	2.58	(1.53–4.36)	2.00	(1.54–2.59)	1.24	(0.97–1.58)
Toothache within a year							
Yes	1.00	1.99	(0.96–4.15)	1.95	(1.42–2.69)	1.22	(0.88–1.69)
No	1.00	2.68	(1.57–4.58)	2.38	(1.79–3.18)	1.33	(1.02–1.74)
Experience dental damages							
Yes	1.00	3.12	(1.31–7.41)	2.93	(1.68–5.10)	1.04	(0.61–1.75)
No	1.00	3.15	(0.45–22.01)	2.48	(1.05–5.88)	1.76	(0.81–3.82)
Female							
Self-reported oral health status							
High	1.00	4.14	(2.43–7.07)	2.41	(0.91–6.41)	0.78	(0.28–2.19)
Middle	1.00	6.34	(1.91–21.04)	1.69	(1.00–2.84)	0.64	(0.37–1.11)
Low	1.00	0.92	(0.25–3.45)	1.59	(1.11–2.29)	1.26	(0.86–1.86)
Educational level							
Middle school or less	1.00	4.25	(0.54–33.29)	1.82	(1.17–2.83)	1.15	(0.73–1.82)
High school	1.00	0.96	(0.18–4.98)	1.91	(1.22–3.01)	1.06	(0.59–1.89)
College and beyond	1.00	2.39	(0.57–10.12)	1.17	(0.61–2.26)	0.83	(0.48–1.45)
Region							
Urban	1.00	3.43	(0.83–14.25)	2.90	(1.92–4.38)	1.20	(0.78–1.83)
Rural	1.00	1.60	(0.54–4.68)	1.15	(0.80–1.65)	0.87	(0.57–1.31)
Dental caries							
Yes	1.00	0.87	(0.19–3.93)	1.47	(0.97–2.25)	0.86	(0.49–1.49)
No	1.00	4.14	(1.20–14.20)	1.91	(1.34–2.74)	1.06	(0.74–1.53)
Toothache within a year							
Yes	1.00	1.13	(0.30–4.32)	1.82	(1.21–2.74)	1.17	(0.76–1.81)
No	1.00	3.52	(1.16–10.68)	1.67	(1.15–2.42)	0.86	(0.57–1.29)
Experience dental damages							
Yes	1.00	2.16	(1.32–3.55)	2.04	(1.63–2.56)	1.33	(1.08–1.66)
No	1.00	2.22	(0.75–6.59)	1.66	(1.25–2.20)	0.93	(0.67–1.29)

frequency of smoking and vaping were not considered in our study. Fifth, electronic cigarettes are still a relatively new technology. As such, few respondents reported using them. Despite their low numbers, weight variables developed by the KNHANES improved the representativeness of the sample. Moreover, electronic cigarette vaping demonstrated significant associations with disease, an effect that would likely remain significant if numbers were increased.

Despite these limitations, our study also has strengths. The KNHANES is conducted by a national institution and is based on random cluster sampling. This makes the data more statistically reliable and representative when compared to surveys performed by private institutions. Furthermore, the KNHANES combines a health interview with a physical examination and nutrition survey, allowing it to be used as a base for creating health-related policies or programs.[37] Therefore, results from the current study can be used as a baseline for motivating users to stop using cigarettes and aid in the creation of anti-smoking policies.

As smoking increases the possibility of periodontal disease and affects the treatment of other oral diseases,[28,29] smoking cessation is of the utmost importance. Prior research shows that smokers who quit demonstrate a normalization of oral health toward non-smoker levels after quitting.[38,39] Smoking is currently the principal public health issue globally,[40] as it causes direct damage to the respiratory system.[41] In addition, smoking is an important direct cause of dental disease[38] and an important environmental factor in the development of other oral diseases.[39,42] In addition, smoking is an important factor in tooth loss, and an overall obstacle to dental health.[29,43] Electronic cigarette use is associated with increased rates of smoking conventional cigarettes. Therefore, preventing all forms of tobacco use, including electronic cigarettes, is important.[44]

The current study identified a significant relationship between periodontal disease and electronic/conventional cigarette use. Our findings suggest that people who vaping or smoking cigarettes demonstrated a higher probability of periodontal disease when compared to both non-users and ex-users. As smoking is detrimental to health, many countries have developed smoking policies that ban or restrict smoking. This can provide protection for non-smokers from the harmful health effects of exposure to secondhand smoke and provide a supportive environment for smokers who want to quit smoking.[45] Many anti-smoking laws are also being implemented in South Korea. Nevertheless, a 2016 national survey showed that about 40% of men still smoked.[6] Even worse, there is a lack of studies about health risks of electronic cigarettes, and most existing laws only cover conventional cigarettes.[8,46] Understanding the country-specific factors that affect smoking behavior and selecting appropriate anti-smoking measures could greatly reduce smoking.[47] Policymakers should carefully make regulations including electronic cigarettes. Taken together, the results of the current study could motivate both electronic cigarette vapers and conventional cigarette smokers to quit by highlighting the association of conventional cigarette smoking and electronic cigarette vaping with periodontal disease. Furthermore, these results can be used to help create new anti-smoking policies.

REFERENCES

1. World Health Organization. World No Tobacco Day 2017: tobacco threatens development, strong control measures needed. Geneva. 2017;1.
2. Pfeifer GP, Denissenko MF, Olivier M, et al. Tobacco smoke carcinogens, DNA damage and p53 mutations in smoking-associated cancers. *Oncogene*. 2002;21:7435.
3. International Agency for Research on Cancer. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. 1986:37-375.
4. Parkin DM, Pisani P, Lopez AD, et al. At least one in seven cases of cancer is caused by smoking. Global estimates for 1985. *Int J Cancer*. 1994;59:494-504.
5. Hecht SS. Cigarette smoking: cancer risks, carcinogens, and mechanisms. *Langenbecks Arch Surg*. 2006;391:603-613.
6. Korea Centers for Disease Control and Prevention. Trend of current smoking rates among Korean adults aged 19 and over, 2007–2016. *Korea Centers for Disease Control and Prevention*. 2018;11:712.
7. Lee S, Kimm H, Yun JE, et al. Public health challenges of electronic cigarettes in South Korea. *J Prev Med Public Health*. 2011;44:235-241.
8. Shin JW, Shin MC. The effects of electronic cigarette consumers, self-congruity, self-esteem, and intention to quit smoking on the attitude toward electronic cigarette. *Korea Assoc Bus Educ*. 2015;30:223-258.
9. Martínez-Sánchez JM, Ballbè M, Fu M, et al. Electronic cigarette use among adult population: a cross-sectional study in Barcelona, Spain (2013–2014). *BMJ Open*. 2014;4:e005894.
10. Korea National Statistical Office. Annual report on smoking in 2011. Statistic Korea. Daejeon. 2011.
11. Jeon C, Jung KJ, Kimm H, et al. E-cigarettes, conventional cigarettes, and dual use in Korean adolescents and university students: prevalence and risk factors. *Drug Alcohol Depend*. 2016;168:99-103.
12. Korea Ministry of Health and Welfare. The Report of the Korean National Health and Nutritional Examination Survey in 2016. Korea Ministry of Health and Welfare. Sejong. 2018.
13. Tomar SL, Fox CH, Connolly GN. Electronic cigarettes: the tobacco industry's latest threat to oral health. *J Am Dent Assoc*. 2015;146:651-653.
14. Loe H. Periodontal disease: the sixth complication of diabetes mellitus. *Diabetes Care*. 1993;16:329.
15. Grossi SG, Genco RJ, Machtet EE, et al. Assessment of risk for periodontal disease. II. Risk indicators for alveolar bone loss. *J Periodontol*. 1995;66:23-29.

16. Korea Ministry of Health and Welfare. The Report of the Korean Nationwide Health and Nutritional Examination Survey in 2013–2015. Korea Ministry of Health and Welfare. Sejong. 2017.
17. Hong MH. The relationship between oral health behavior, chronic disease and periodontal disease in middle and older adults according to gender. *J Acad Ind Technol*. 2018;19:403-410.
18. Ji MG. Relationship between adults' smoking realities and periodontal disease – 2009 Korea National Health and Nutrition Examination Survey data. *J Korean Inst Commun Inf Sci*. 2012;7:917-924.
19. Javed F, Kellesarian SV, Sundar IK, et al. Recent updates on electronic cigarette aerosol and inhaled nicotine effects on periodontal and pulmonary tissues. *Oral Dis*. 2017;23:1052-1057.
20. Pradeep AR, Ramchandraprasad MV, Bajaj P, et al. Protein carbonyl: an oxidative stress marker in gingival crevicular fluid in healthy, gingivitis, and chronic periodontitis subjects. *Contemp Clin Dent*. 2013;4:27-31.
21. Baltacıoğlu E, Akalın FA, Alver A, et al. Protein carbonyl levels in serum and gingival crevicular fluid in patients with chronic periodontitis. *Arch Oral Biol*. 2008;53:716-722.
22. World Health Organization. *Oral Health Survey. Basic Method*. 4th ed. Geneva, Switzerland: World Health Organization. 1997.
23. Kim JW, Kong KA, Kim HY, et al. The association between bone mineral density and periodontitis in Korean adults (KNHANES 2008–2010). *Oral Dis*. 2014;20:609-615.
24. Lee DH, Lee YH. Association between sleep duration, dental caries, and periodontitis in Korean adults: the Korea National Health and Nutrition Examination Survey, 2013∼2014. *J Korean Soc Dent Hyg Sci*. 2017;17:38-45.
25. Obeid P, Bercy P. Effects of smoking on periodontal health: a review. *Adv Ther*. 2000;17:230-237.
26. Mullally BH, Linden GJ. Molar furcation involvement associated with cigarette smoking in periodontal referrals. *J Clin Periodontol*. 1996;23:658-661.
27. Wang H-L, Burgett FG, Shyr Y, et al. The influence of molar furcation involvement and mobility on future clinical periodontal attachment loss. *J Periodontol*. 1994;65:25-29.
28. The American Academy of Periodontology. Parameter on plaque-induced gingivitis. *J Periodontol*. 2000;71:851-852.
29. Yang JY, Park KS. The effects of smoking on oral environment. *J Korean Soc Dent Hyg Sci*. 2001;1:60-66.
30. Johnson GK, Guthmiller JM. The impact of cigarette smoking on periodontal disease and treatment. *Periodontol 2000*. 2007;44:178-194.
31. Kinane DF, Chestnutt IG. Smoking and periodontal disease. *Crit Rev Oral Bio Med*. 2000;11:356-365.
32. Jung JO, Chun JY, Lee KH. The relationship between smoking and periodontal diseases in Korean adults: based on the data from the Korean National Health and Nutrition Examination Survey 2010. *J Korean Soc Dent Hyg Sci*. 2013;13:481-489.
33. Albandar JM, Streckfus CF, Adesanya MR, et al. Cigar, pipe, and cigarette smoking as risk factors for periodontal disease and tooth loss. *J Periodontol*. 2000;71:1874-1881.
34. Chan L, Hart LG, Goodman DC. Geographic access to health care for rural medicare beneficiaries. *J Rural Health*. 2006;22:140-146.
35. Baelum V, Papapanou PN. CPITN and the epidemiology of periodontal disease Commentary. *Community Dent Oral Epidemiol*. 1996;24:367-368.
36. Kim DW, Park JC, Rim T-T, et al. Socioeconomic disparities of periodontitis in Koreans based on the KNHANES IV. *Oral Dis*. 2014;20:551-559.
37. Kweon S, Kim Y, Jang MJ, et al. Data resource profile: the Korea National Health and Nutrition Examination Survey (KNHANES). *Int J Epidemiol*. 2014;43:69-77.
38. Warnakulasuriya S, Dietrich T, Bornstein MM, et al. Oral health risks of tobacco use and effects of cessation. *Int Dent J*. 2010;60:7-30.
39. Bergstrom J. Cigarette smoking as risk factor in chronic periodontal disease. *Community Dent Oral Epidemiol*. 1989;17:245-247.
40. Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. *N Engl J Med*. 2014;370:60-68.
41. Ozguner F, Koyu A, Cesur G. Active smoking causes oxidative stress and decreases blood melatonin levels. *Toxicol Ind Health*. 2005;21:21-26.
42. Linden GJ, Mullally BH. Cigarette smoking and periodontal destruction in young adults. *J Periodontol*. 1994;65:718-723.
43. Axelsson P, Paulartder J, Lindhe J. Relationship between smoking and dental status in 35-, 50-, 65-, and 75-year-old individuals. *J Clin Periodontol*. 1998;25:297-305.
44. Agaku IT, Arrazola RA, Caraballo RS, et al. Intentions to smoke cigarettes among never-smoking US middle and high school electronic cigarette users: National Youth Tobacco Survey, 2011–2013. *Nicotine Tob Res*. 2014;17:228-235.
45. Callinan JE, Clarke A, Doherty K, Kelleher C. Legislative smoking bans for reducing secondhand smoke exposure, smoking prevalence and tobacco consumption. *Cochrane Database Syst Rev*. 2010;(4):CD005992.
46. Lempert LK, Grana R, Glantz SA. The importance of product definitions in US e-cigarette laws and regulations. *Tob Control*. 2016;25:e44.
47. Chung W, Kim H, Lim S, et al. Factors influencing cigarette smoking and quantified implications for anti-smoking policy: evidence from South Korea. *Int J Public Health*. 2009;54:409-419.