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RESEARCH ARTICLE **OPEN ACCESS**

Association of Tobacco Exposure Patterns with Periodontal Health: A Cross-Sectional Analysis of NHANES Data

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Abstract:

Introduction: Periodontitis is an inflammatory disease and a leading cause of adult tooth loss. While the effects of traditional tobacco use on periodontal health are well documented, research on electronic cigarette (e-cigarette) use and secondhand smoke exposure is limited. This study evaluated whether active smoking, passive smoking, e-cigarette use, and combined exposures were associated with periodontitis severity using 2013-2014 National Health and Nutrition Examination Survey (NHANES) data.

Materials and Methods: A total of 3,618 adults were included. Periodontal staging followed the 2017 American Academy of Periodontology Classification. Associations between smoking status and periodontal staging were examined using multivariable ordinal logistic regression, adjusting for age, gender, diabetes status, socioeconomic status, race/ethnicity, and education level.

Results: Current tobacco-only smokers had 2.95 times higher odds of more severe periodontitis compared with never smokers ($P<0.001$). Current e-cigarette-only users had 2.70 times higher odds ($P=0.011$), and dual users had 2.51 times higher odds ($P=0.010$) of more severe periodontitis. Past tobacco smokers had 1.27 times higher odds ($P=0.003$), and participants exposed to secondhand smoke had 1.54 times higher odds ($P=0.028$).

Discussion: All tobacco exposure groups, including e-cigarette-only users and dual users, were significantly associated with greater odds of periodontitis severity. The results emphasize the emerging concern of newer nicotine delivery products.

Conclusion: All tobacco exposure groups were significantly associated with increased odds of periodontitis severity, including e-cigarette-only users and dual users. Dental professionals should educate patients on the established oral health risks of tobacco use in all forms, including e-cigarettes and secondhand smoke exposure.

Keywords: Periodontitis, Electronic cigarettes, Secondhand smoke, NHANES, Tobacco, Periodontal disease severity, Dental public health.

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1. INTRODUCTION

Periodontitis is a chronic inflammatory disease and a leading cause of adult tooth loss [1]. It is a multifactorial condition, with *Porphyromonas gingivalis* recognized as a key pathogen within the periodontal biofilm, and microbial dysbiosis regarded as a primary contributor to the initiation and progression of the disease [2]. Disease progression is also driven by the host immune response to pathogenic microorganisms, leading to the destruction of

gingival connective tissue and the resorption of alveolar bone. This process is associated with a shift from aerobic, Gram-positive bacteria to Gram-negative "red complex" pathogens, which are linked to elevated levels of pro-inflammatory cytokines [3]. The impact of periodontitis extends beyond the oral cavity. Chronic periodontal inflammation contributes to systemic inflammatory burden and has been associated with increased risk of cardiovascular disease, diabetes complications, dementia, adverse pregnancy outcomes, and respiratory conditions, highlighting that periodontitis is not only a local oral disease but also a significant public health concern with systemic implications [4-6]. There are various risk factors that can contribute to the development of periodontitis, including poor or inadequate oral hygiene, genetic predisposition, osteoporosis, diabetes, and environmental influences such as tobacco use, which can exacerbate disease progression.

Tobacco smoke is a common environmental exposure factor and remains a significant global public health concern due to its well-established role in the development and progression of numerous diseases [7, 8]. The association between smoking and periodontitis has been extensively documented, with current literature consistently demonstrating that tobacco use contributes to both the onset and advancement of periodontal disease [9-11]. Exposure to tobacco smoke and aerosols has been shown to impair microcirculatory function, alter immune responses, and disrupt normal wound healing, thereby accelerating periodontal breakdown. Additionally, evidence indicates that individuals exposed to tobacco, whether through active smoking, vaping, or environmental (secondhand) exposure, are at increased risk for periodontitis compared to those with no exposure [11-13].

The risk of periodontal disease from smoking is not unique to cigarette smoking. Public awareness of the harms of cigarette smoking has further contributed to the adoption of alternative nicotine delivery devices, particularly beginning in the mid-2000s. Electronic Nicotine Delivery Systems (ENDS), also known as electronic cigarettes (e-cigarettes), were introduced into the United States market in 2007 and have since experienced substantial growth in popularity [14]. These products were developed and marketed as potentially safer alternatives to traditional cigarette smoking and as tools for smoking cessation, in response to increasing evidence of the cancer risk and other health complications associated with conventional tobacco use [15, 16]. In recent years, the prevalence of e-cigarette use has risen notably among young adults, current and former smokers, and individuals of lower socioeconomic status [17]. One study estimated that approximately 600,000 Americans under 21 years of age used JUUL, a brand of electronic cigarette, daily in 2019 [18]. And in 2021, individuals aged 18 to 24 years demonstrated a consistently high prevalence of e-cigarette use, with more than 18.6% reporting current use and over 9.0% reporting daily use [19]. Despite their widespread adoption, the latest guidance from the Centers for Disease Control and Prevention (CDC) does not support e-cigarettes as approved smoking cessation aids and emphasizes that more definitive evidence is needed to determine their effectiveness in promoting long-term cessation [20]. For the purposes of this study, electronic cigarettes (e-cigarettes) and vapes are collectively referred to as e-cigarettes. The increased use of e-cigarette products has brought a new public health concern, with emerging evidence indicating that their use can contribute to increased risk of periodontal disease [21-23]. Recent systematic reviews and meta-analyses have further demonstrated that e-cigarette users exhibit greater risk of periodontal disease compared to non-smokers, although with generally less severe outcomes than conventional cigarette smokers [24, 25].

The association between conventional cigarette smoking and periodontitis is well established and has been demonstrated in prior NHANES-based investigations; using NHANES III data, Tomar and Asma estimated that current smoking accounted for 41.9% of periodontitis cases among U.S. adults [26]. Secondhand smoke exposure and periodontal disease have similarly been examined using national survey data, including a NHANES III analysis by Arbes *et al*. reporting 60% higher odds of periodontitis among never-smokers exposed to environmental tobacco smoke [27]. However, evidence regarding e-cigarette use and periodontal health remains comparatively limited and inconsistent [28]. Analyses of the Population Assessment of Tobacco and Health (PATH) study have examined self-reported gum disease in relation to tobacco-use patterns and electronic nicotine product use [28, 29]. Additionally, mechanistic reviews have shown biological pathways by which e-cigarette aerosol exposure may affect periodontal tissues [30]. There are few studies that have evaluated multiple forms of tobacco exposure, including conventional smoking, e-cigarette use, dual use, and secondhand smoke exposure, within a single analytic framework using clinically assessed, AAP-classified periodontal status. The purpose of this study is to evaluate whether active smoking, passive smoking, e-cigarette use, and combined exposures are associated with greater severity of periodontitis. We hypothesize that individuals with any of these exposures exhibited significantly more severe periodontal disease compared with those unexposed. To test this hypothesis, we analyzed data from the 2013–2014 National Health and Nutrition Examination Survey (NHANES) to assess the prevalence and severity of periodontitis across exposure groups.

2. MATERIALS AND METHODS

2.1. Study Design

This study is a cross-sectional analysis of data from the 2013–2014 cycle of the National Health and Nutrition Examination Survey (NHANES), a nationally representative survey administered by the National Center for Health Statistics (NCHS), a division of the Centers for Disease Control and Prevention (CDC), designed to assess the health and nutritional status of the U.S. population. The 2013-2014 NHANES dataset was selected for the current study as it remains the most recent publicly available NHANES cycle that includes comprehensive periodontal examination data.

2.2. Study Sample

A total of 3,618 subjects aged 18 years and older who had complete periodontal examination data and self-reported smoking status were included in the study. Participants were selected from the NHANES 2013–2014 population based on the availability of full periodontal measurements and relevant questionnaire responses. Individuals were included if they were 18 years or older, had complete periodontal examination data, and reported their smoking status. Participants were excluded if any periodontal measurements or smoking status information were missing, or if demographic or covariate data necessary for analysis were incomplete. For regression analyses, 6 individuals were excluded due to missing data on model covariates, resulting in a final analytic sample of 3,612 participants.

2.3. Study Variables

The primary predictor variable was smoking exposure status, categorized into six groups: never smokers, current tobacco-only smokers, current e-cigarette-only users, dual users (tobacco and e-cigarettes), past tobacco smokers, and individuals with secondhand smoke exposure. The secondhand smoke exposure group consisted of never smokers who reported regular exposure to environmental tobacco smoke in the household or workplace, compared against never smokers without such exposure. The primary outcome variable was periodontal disease stage, which was defined according to the 2017 American Academy of Periodontology (AAP) Classification of Periodontal and Peri-Implant Diseases and Conditions [31]. Stages ranged from I to IV, with higher stages indicating greater clinical attachment loss and probing depths. Serum cotinine concentrations were obtained from NHANES laboratory data, were considered biomarkers of the exposure of interest, and are presented for descriptive purposes.

Covariates included in the multivariable regression models were age, gender, diabetes status, socioeconomic status (poverty-income ratio), race/ethnicity, and education level. Race/ethnicity was categorized as Mexican American, Other Hispanic, Non-Hispanic White (reference), Non-Hispanic Black, Non-Hispanic Asian, and Other (including multi-racial). Education was categorized as none or some high school (reference), high school graduate/GED equivalent, some college or associate degree, and college graduate or above. Participants with missing data on education status (n=2) or other model covariates were excluded from regression analyses.

2.4. Data Collection and Analyses

Full-Mouth Periodontal Examinations (FMPE) in the 2013 to 2014 NHANES study were conducted by trained dental professionals using standardized procedures. Measurements included clinical attachment loss and probing depth at six sites per tooth for all eligible teeth, except for third molars.

Smoking status and secondhand smoke exposure were self-reported using standardized NHANES questionnaires. Secondhand smoke exposure was defined based on participant report of regular exposure to tobacco smoke in the household or workplace. Serum cotinine concentrations were obtained from NHANES laboratory data and are presented descriptively as an objective biomarker of tobacco exposure. All data were accessed from the publicly available NHANES database. Descriptive statistics including means, standard deviations, counts, and percentages were calculated. Multivariable ordinal logistic regression models were created to analyze the association between periodontal disease and smoking status while controlling for relevant confounders. Sampling weights, strata, and primary sampling units were not incorporated into the regression analyses; therefore, results reflect associations within the analytic sample rather than weighted, nationally representative estimates. Data management and analyses were performed using Stata 18 (Stata Corp LLC, College Station, TX) and SAS 9.4 (SAS Institute Inc., Cary, NC). Results were considered statistically significant when $P < 0.05$.

3. RESULTS

A total of 3,618 individuals were initially included in the study. The mean age of study participants was 51.9 years, and 48.4% of the sample were male. As shown in Table **1**, 53.5% of individuals were never smokers, and 0.7% were current e-cigarette-only smokers (Table **1**).

For regression analyses, 6 individuals were excluded due to missing data on model covariates, resulting in a final analytic sample of 3,612 participants. Multivariable ordinal logistic regression was used to estimate the odds of being in a more severe stage of periodontitis for each smoking exposure group, adjusting for age, gender, diabetes status, socioeconomic status, race/ethnicity, and education level.

Compared to never smokers, current tobacco-only smokers had significantly higher odds of more severe periodontitis (odds ratio [OR], 2.95; 95% confidence interval [CI], [2.45-3.57]; $P<0.001$). Past tobacco smokers also had higher odds of more severe periodontitis compared to never smokers (OR, 1.27; 95% CI, [1.08-1.50]; $P=0.003$). Individuals exposed to secondhand smoke had significantly higher odds of more severe periodontitis compared with never smokers (OR, 1.54; 95% CI, [1.04-2.27]; $P=0.028$). Current e-cigarette-only users had significantly higher odds of more severe periodontitis compared to never smokers (OR, 2.70; 95% CI [1.25-5.80]; $P=0.011$), as did dual users of tobacco and e-cigarettes (OR, 2.51; 95% CI [1.25-5.04]; $P=0.010$) (Table **2**).

Diabetes status was independently associated with periodontitis severity. Participants with diabetes had 1.51 times higher odds of more severe staging compared to those without diabetes ($P<0.001$), after adjusting for smoking status, age, gender, SES, race/ethnicity, and education level (Table **2**). No significant difference in periodontitis severity was observed between individuals without diabetes and those with borderline diabetes.

Table 1. Demographic and socioeconomic characteristics of the study population by smoking status, NHANES 2013–2014 (N = 3,612). PIR = Poverty Income Ratio.

	Never Smoker	Current Smoker	Current E-cigarette only Smoker	Current Tobacco and E-cigarette Smoker	Past Tobacco Smoker	Secondhand Smoker Exposure (all never smokers)	Total, N
Sex							
Male	790 (45.1)	350 (20.0)	16 (0.9)	9 (0.5)	540 (30.9)	45 (2.6)	1,750
Age group, y							
18-39	468 (54.7)	197 (23.0)	9 (1.1)	9 (1.1)	139 (16.2)	34 (4.0)	856
40-59	879 (55.2)	320 (20.1)	13 (0.8)	20 (1.3)	316 (19.8)	45 (2.8)	1,593
≥60	587 (50.5)	118 (10.2)	4 (0.3)	2 (0.2)	426 (36.6)	26 (2.2)	1,163
Race/Ethnicity							
Mexican American	297 (60.6)	56 (11.4)	0 (0.0)	1 (0.2)	128 (26.1)	8 (1.6)	490
Other Hispanic	173 (53.7)	46 (14.3)	4 (1.2)	0 (0.0)	94 (29.2)	5 (1.6)	322
Non-Hispanic White	751 (48.1)	302 (19.4)	13 (0.8)	24 (1.5)	429 (27.5)	41 (2.6)	1,560
Non-Hispanic Black	355 (50.6)	167 (23.8)	3 (0.4)	5 (0.7)	131 (18.7)	41 (5.8)	702
Non-Hispanic Asian	316 (70.7)	39 (8.7)	4 (0.9)	1 (0.2)	79 (17.7)	8 (1.8)	447
Other (including multi-racial)	42 (46.2)	25 (27.5)	2 (2.2)	0 (0.0)	20 (22.0)	2 (2.2)	91
Socioeconomic Status							
PIR≤1	248 (38.9)	206 (32.3)	5 (0.8)	7 (1.1)	140 (22.0)	31 (4.9)	637
PIR>1 and <4	896 (52.2)	311 (18.1)	11 (0.6)	17 (1.0)	425 (24.8)	56 (3.3)	1,715
PIR≥4	790 (62.7)	118 (9.4)	10 (0.8)	7 (0.6)	317 (25.2)	18 (1.4)	1,260
Education							
None or some high school	326 (45.7)	164 (23.0)	6 (0.8)	7 (1.0)	168 (23.6)	42 (5.9)	713
High school graduate/GED	333 (42.5)	203 (25.9)	5 (0.6)	8 (1.0)	212 (27.1)	22 (2.8)	783
Some College/AA degree	556 (51.2)	204 (18.8)	8 (0.7)	14 (1.3)	280 (25.8)	25 (2.3)	1,087
College graduate or above	719 (69.9)	64 (6.2)	7 (0.7)	2 (0.2)	221 (21.5)	16 (1.6)	1,029
Total Frequency	1,934 (53.5)	635 (17.6)	26 (0.7)	31 (0.9)	881 (24.4)	105 (2.9)	3,612

Table 2. Multivariable ordinal logistic regression assessing the association between smoking status, secondhand smoke exposure, diabetes, SES, and periodontal disease severity (NHANES 2013–2014; N = 3,612). Analyses were restricted to participants with complete data for all covariates. Odds ratios represent the likelihood of being in a more severe periodontal stage compared to the reference groups (never smokers, individuals without diabetes, PIR ≤1, non-Hispanic white individuals, individuals with none or some high school education), adjusted for age, gender, and all other variables in the model.

		Confidence Interval		
Smoking Status	**Odds Ratio**	**Lower**	**Upper**	***P* Value**
Current tobacco only smoker	2.95	2.45	3.57	<0.001
Current e-cigarette only smoker	2.70	1.25	5.80	0.01
Current tobacco and e-cigarette smoker	2.51	1.25	5.04	0.01
Past tobacco smoker	1.27	1.08	1.50	0.003
Secondhand smoker exposure (all never smokers)	1.54	1.04	2.27	0.03
Diabetes Status				
Yes	1.51	1.24	1.83	<0.001
Borderline	1.26	0.88	1.79	0.21
Socioeconomic Status				
PIR>1 and <4	0.66	0.55	0.79	<0.001
PIR≥4	0.41	0.33	0.50	<0.001
Race/Ethnicity				
Mexican American	1.48	1.20	1.83	<0.001
Other Hispanic	1.78	1.40	2.27	<0.001
Non-Hispanic Black	2.34	1.95	2.80	<0.001

(Table 2) contd.....

		Confidence Interval		
Non-Hispanic Asian	1.81	1.46	2.23	<0.001
Other	1.87	1.24	2.83	0.003
Education				
High school or GED	0.79	0.64	0.96	0.02
Some college or AA degree	0.47	0.39	0.57	<0.001
College graduate or above	0.31	0.25	0.38	<0.001

Table 3. Serum cotinine levels by smoking status, NHANES 2013-2014. Serum cotinine measurements were available for 3,492 participants; some participants in the study population (N = 3,618) did not have valid cotinine measurements and were therefore excluded from this analysis. Median (interquartile range, IQR) values are reported.

Smoking Status	N	Median (IQR) Cotinine (ng/mL)	% ≥ 3 ng/mL
Never smoker	1,872	0.016 (0.029)	3.95
Current tobacco-only smoker	613	241 (196)	96.57
Current e-cigarette only smoker	26	179.5 (176.4)	96.15
Current tobacco and e-cigarette smoker	29	226 (150)	100.0
Past tobacco smoker	848	0.025 (0.117)	12.62
Secondhand smoker exposure (all never smokers)	104	0.395 (2.991)	25.0
Total	3,492	0.029 (2.084)	24.43

Socioeconomic status was also associated with periodontitis severity. Participants with Poverty-Income Ratio (PIR) between >1 and <4 had lower odds of more severe periodontitis compared to those with PIR≤1 (OR, 0.66; 95% CI [0.55-0.79]; *P<0.001*), and participants with PIR≥4 had significantly lower odds compared with those with PIR≤1 (OR, 0.41; 95% CI [0.33-0.50]; *P<0.001*).

A chi-square test indicated that binary serum cotinine levels (≥3 ng/mL *vs.* <3 ng/mL) were significantly associated with smoking status (*P<0.001*). Median serum cotinine levels differed significantly between most smoking status groups based on Kruskal-Wallis tests and Dunn's post hoc comparisons with Bonferroni correction, except for comparisons between current tobacco only, current e-cigarette only, and dual-users, which were not statistically significant (*P>0.999*).

Serum cotinine data were available for 3,492 of the 3,618 individuals and are presented descriptively in Table **3**. The highest percentages of individuals with serum cotinine ≥3 ng/mL were observed among current tobacco and e-cigarette smokers (100.0%), current tobacco-only smokers (96.6%), and current e-cigarette-only smokers (96.2%) (Table **3**).

4. DISCUSSION

The purpose of this study was to evaluate whether active conventional smoking, passive smoking, e-cigarette use, and combined exposures were associated with greater severity of periodontitis. It was hypothesized that individuals with any of these exposures would demonstrate significantly more severe periodontitis compared to those with no exposure. We addressed this hypothesis by analyzing data from the 2013-2014 National Health and Nutrition Examination Survey (NHANES) to compare the prevalence and severity of periodontitis across exposure groups. The findings support the hypothesis that individuals with any of these exposures demonstrate significantly greater odds of more severe periodontitis compared to never smokers. All five exposure groups demonstrated statistically significant associations with greater periodontitis severity, with current tobacco-only smokers showing the highest odds (OR 2.95), followed by e-cigarette-only users (OR 2.70) and dual users (OR 2.51). These results cannot establish causation given the cross-sectional design; however, they provide evidence that both direct and indirect tobacco exposure patterns are associated with adverse periodontal outcomes across multiple exposure types.

The present findings demonstrate that both e-cigarette-only users and dual users had significantly greater odds of more severe periodontitis compared to never smokers, highlighting the growing public health concern of e-cigarette use and its association with periodontal disease. Although e-cigarettes are often marketed as a safer alternative to conventional smoking, studies show that they produce similar harmful effects on oxidative stress markers and inflammatory cytokines [32].

Mechanistically, tobacco smoke and e-cigarette aerosol exposure have each been shown to impair periodontal tissue homeostasis through related but distinct pathways. Conventional cigarette smoke contains thousands of chemical constituents, including nicotine and carbon monoxide, that impair gingival microvascular blood flow and reduce neutrophil chemotaxis and phagocytic function, blunting the local immune response to periodontal pathogens. E-cigarette aerosol, although free of combustion byproducts, still delivers nicotine and contains reactive carbonyl compounds and ultrafine

particulates that have been shown to increase oxidative stress and pro-inflammatory cytokine release in gingival epithelial and fibroblast cell lines, and to alter the oral microbiome toward a more dysbiotic, pathogen-favoring profile [33]. These pathways provide biological plausibility for the associations observed in the present study, although direct evidence in human periodontal tissue, particularly for e-cigarette aerosol, remains more limited than for conventional smoke [30, 34].

One study that analyzed data from the 2016 Behavioral Risk Factor Surveillance System found that poor oral health was more prevalent than good oral health among both daily e-cigarette users and intermittent e-cigarette users [35]. Another study using data from the Korean NHANES between 2013-2015 found that e-cigarettes and conventional tobacco smoking were each significantly associated with increased periodontal disease rates [36]. A systematic review that pooled 13 studies found that clinical attachment loss was higher in e-cigarette users compared to non-smokers and former smokers, but higher in smokers compared to e-cigarette users [34]. While e-cigarette use has been found to adversely affect periodontal health and increase the severity of periodontitis, it is also important to recognize that in many cases individuals who are smoking e-cigarettes are also traditional tobacco smokers. A study by AlQobaly *et al*. analyzed NHANES data from 2015-2018 that included self-reported periodontal status rather than diagnosis from a dental professional, and initially found that e-cigarette use was associated with self-reported periodontal disease. After further analyses, the authors found that although e-cigarette use was associated with periodontitis, the association was significant only among current smokers [37]. Similarly, a clinical study examining response to non-surgical periodontal therapy found that e-cigarette users showed impaired treatment response compared to non-smokers, further supporting an adverse periodontal effect of e-cigarette use [38]. This pattern is broadly consistent with the present findings, in which all active tobacco exposure groups, including e-cigarette-only users and dual users, demonstrated significantly greater odds of periodontitis severity compared to never smokers, while the magnitude of association was greatest for current tobacco-only smokers. This finding indicates that detailed analysis in further studies can aid in determining the exact adverse effects of e-cigarette-only use on periodontal health *versus* the effects on periodontal health of dual users.

In contrast to the comparatively limited and mixed evidence on e-cigarette use, the association between secondhand smoke exposure and periodontal disease risk is more consistently established. A cross-sectional study conducted by Liu *et al*. using NHANES data from 2009-2014 found that individuals with tobacco smoke exposure compared to participants without tobacco smoke exposure had increased odds of having periodontitis [11]. In another study that used NHANES data from the 2009-2012 examination cycle, the authors found that there was a 28% increase in the odds of having periodontitis for individuals exposed to secondhand smoke compared to those who were not [13]. These findings further demonstrate the detrimental impact of environmental smoke exposure on individuals who do not smoke. This highlights the continued importance of addressing secondhand smoke as a significant public health concern and the need for ongoing preventive and educational initiatives. Approximately one-quarter of non-smokers in our present study demonstrated elevated serum cotinine levels, showing that exposure to secondhand smoke remains a prevalent and concerning issue.

5. STUDY LIMITATIONS

The present study has several limitations that should be noted. The cross-sectional design reduces confidence in causal associations, and survey-weighted analyses were not conducted. As a result, the reported odds ratios and confidence intervals describe associations within the analytic sample and should not be interpreted as nationally representative estimates of the U.S. population. Smoking behavior and type were self-reported, introducing potential reporting bias due to reliance on participant answers and honesty. Furthermore, many current e-cigarette users may have been former conventional cigarette smokers, which could introduce exposure misclassification and confound the observed associations. The number of participants who reported exclusive e-cigarette use and dual use was relatively small, which may limit the precision of effect estimates for these subgroups despite reaching statistical significance in the current analysis. These exposure groups represent emerging populations of considerable public health interest, and future studies with larger samples would allow for more precise estimation of these associations. Additionally, some potential periodontal risk factors were not incorporated into the regression model. Although the models adjusted for key confounders, residual confounding from unmeasured or unmodeled factors cannot be excluded. The 2013-2014 NHANES cycle was the most recent dataset containing e-cigarette use information and therefore may not fully capture the rapid increase in e-cigarette use in more recent years.

Although the number of e-cigarette–only users in the sample was limited, future studies using more current samples and a larger number of e-cigarette-only users could allow for weighted analyses and more definitive conclusions. Despite these limitations, collecting and analyzing data on e-cigarette use and secondhand smoke exposure remains critical for understanding their impact on periodontal health and for informing public health initiatives.

CONCLUSION

All tobacco exposure groups, including conventional smokers, e-cigarette-only users, dual users, past smokers, and individuals exposed to secondhand smoke, were significantly associated with increased odds of more severe periodontal disease. These findings highlight the importance of raising public health awareness about the oral health risks of tobacco use in all forms, including e-cigarettes and secondhand smoke exposure.

AUTHORS' CONTRIBUTIONS

The authors confirm their contributions to the paper as follows: S.F., Z.C.: Study conception and design: S.P., Z.C., S.F.: Data collection; S.P., Z.C., S.F.: Analysis and interpretation of results; S.F., Z.C.: Draft manuscript. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

AAP	=	American Academy of Periodontology
CDC	=	Centers for Disease Control and Prevention
CI	=	Confidence Interval
ENDS	=	Electronic Nicotine Delivery Systems
FMPE	=	Full-Mouth Periodontal Examination
NCHS	=	National Center for Health Statistics
NHANES	=	National Health and Nutrition Examination Survey
OR	=	Odds Ratio
PATH	=	Population Assessment of Tobacco and Health
PIR	=	Poverty-Income Ratio
SES	=	Socioeconomic Status

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study is a secondary analysis of publicly available, de-identified data from the National Health and Nutrition Examination Survey (NHANES). All NHANES data collection protocols were reviewed and approved by the National Center for Health Statistics (NCHS) Ethics Review Board (ERB), affiliated with the Centers for Disease Control and Prevention (CDC), United States (Protocol #2011-17, continued for the 2013-2014 cycle). As this study utilized only publicly available, de-identified data, no additional institutional ethical approval was required.

HUMAN AND ANIMAL RIGHTS

All procedures involving human participants were conducted in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants at the time of original NHANES data collection.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data analyzed in this study are publicly available from the National Health and Nutrition Examination Survey (NHANES) at https://www.cdc.gov/nchs/nhanes/.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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