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Analysis of the Effects of Xerostomia, Smoking, and Vaping on Orthodontic Considerations: A Comprehensive Survey Study

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بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

﴿ هُوَ الَّذِي أَنزَلَ عَلَيْكَ الْكِتَابَ مِنْهُ آيَاتٌ مُّحْكَمَاتٌ هُنَّ أُمُّ الْكِتَابِ وَأُخَرُ مُتَشَابِهَاتٌ ۖ فَأَمَّا الَّذِينَ فِي قُلُوبِهِمْ زَيْغٌ فَيَتَّبِعُونَ مَا تَشَابَهَ مِنْهُ ابْتِغَاءَ الْفِتْنَةِ وَابْتِغَاءَ تَأْوِيلِهِ ۗ وَمَا يَعْلَمُ تَأْوِيلَهُ إِلَّا اللَّهُ ۗ وَالرَّاسِخُونَ فِي الْعِلْمِ يَقُولُونَ آمَنَّا بِهِ كُلٌّ مِّنْ عِندِ رَبِّنَا ۗ وَمَا يَذَّكَّرُ إِلَّا أُولُو الْأَلْبَابِ ﴾

صدق اللَّهُ العظيم

الآية 7 من سورة آل عمران

Certification of the Supervisor

I certify that this project entitled " Analysis of the Effects of Xerostomia, Smoking, and Vaping on Orthodontic Considerations: A Comprehensive Survey Study " was prepared by the fifth-year students: Ahmed Bigayd, Yusuf Ali, Hussein Fadel, Hussein Yahya, Ali Al-Hadi Hassan, under our supervision at the College of Dentistry/ Babylon University in partial fulfilment of the graduation requirements for the bachelor's degree in Dentistry.

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Contents

Abstract

Background: At its outset, vaping was heralded as a safer alternative to traditional smoking and a promising tool for quitting. However, as time has passed, the cumulative adverse effects of this new method on general and dental health have become apparent. While xerostomia is known to be associated with cigarette smoking, its relationship with vaping remains insufficiently researched.

Material and methods: A questionnaire was designed to collect demographic data including age, employment status, and educational level. And relative questions to estimate the xerostomia via a 5-point scale.

Results: A total of 850 participants (25.4% cigarette smokers, 63.8% vapers) were included in the final analysis. The analysis showed that cigarette smokers had significantly higher xerostomia scores than the other two groups. Further analysis showed that subjects in the cigarette smoker group, with high school education or below, had significantly higher scores than other educational levels.

Conclusions: Xerostomia is an expected and highly perceived symptom among cigarette smokers The study uncovered demographic differences in smoking and vaping habits, influenced by age, gender, employment, and education. Cigarette smokers tended to be older, while vapers started using electronic devices at a younger age. Employed individuals leaned towards smoking, while the unemployed engaged in both smoking and vaping, particularly those with lower education. Xerostomia symptoms were linked to both smoking and vaping, with employed individuals reporting higher rates compared to the unemployed, suggesting potential correlations with employment status and educational level.

Key words: tobacco smoking, vaping, e-cigarettes, xerostomia.

Aim of the study

The aim of this cross-sectional study is to investigate the association between self-reported xerostomia symptoms and vaping as well as cigarette smoking behaviors, while examining the influence of demographic factors such as age, employment status, and educational level, and assessing their effects on oral health outcomes, particularly in relation to orthodontic health.

Chapter one

Introduction

Introduction

Saliva is an essential body fluid that contributes to the protection and preservation of the oral cavity and plays a major role in maintaining oral health and comfort. It is produced by the three pairs of major salivary glands and hundreds of minor salivary glands. Its value is seldom appreciated. Saliva is necessary to moisten the mouth, to lubricate food for easier swallowing, to protect oral hard and soft tissues, to modulate oral microbial populations, to provide initial digestive enzymes, and to promote soft tissue repair and oral cleansing {1}. Salivary gland hypofunction is a condition in which unstimulated or stimulated salivary flow is significantly reduced and can also result in alterations of the chemical composition of saliva. It is generally defined as an unstimulated whole saliva flow rate of less than 0.1–0.2 mL/min, and a stimulated whole saliva flow rate of less than 0.7 mL/min, Figure 1. Dry mouth, usually called xerostomia (Zeer-oh-stomia), is a common symptom most often caused by a decrease in the amount of saliva or a change in the quality of saliva. The perception of dry mouth is sometimes, but not necessarily accompanied by a reduction in salivary flow {2}{18}. Although SGH can be a major cause for deleterious effects on a patient's oral health, xerostomia can also have a major impact on a patient's oral health and quality of life. Symptoms of xerostomia include halitosis, oral soreness and burning, difficulty swallowing and talking, and altered taste. Dry mouth is typically caused by a multitude of factors including: medication side effects, various disease states, head & neck irradiation, dehydration, surgery, smoking, and mouth breathing.

Many people have crowded or crooked teeth. Orthodontic treatment will straighten the teeth or move them into a better position. This can improve their appearance and the way the teeth bite together, while also making them easier to clean.in the other hand {3}{19}, orthodontic treatment affect by many factors that imped the outcomes of treatment and one of these factors is the xerostomia or dry mouth Xerostomia and SGH can also increase the risk of dental caries, and can contribute to periodontal diseases and

oral infections such as candidiasis , patients with a dry mouth often sip or suck sweet and/or acidic drinks and confectionery to relieve their symptoms and this can also increase the risk of dental caries.orthodontic treatment generally improve plaque accumulation around the orthodontic braces ,so it need to flushes by flow of saliva ,but in patient with xerostomia this process will be impeded so the rate of caries will increase and then outcomes of treatment will affected. Dry mouth also cause periodontal disease in advanced stages such as gingivitis and periodontitis which play an intrinsic role on obstructing the movement of the tooth.it is even increase the incidence of ulcers and lesions at the sites of orthodontic elements ,especially in removable orthodontic appliance {4}{21}.

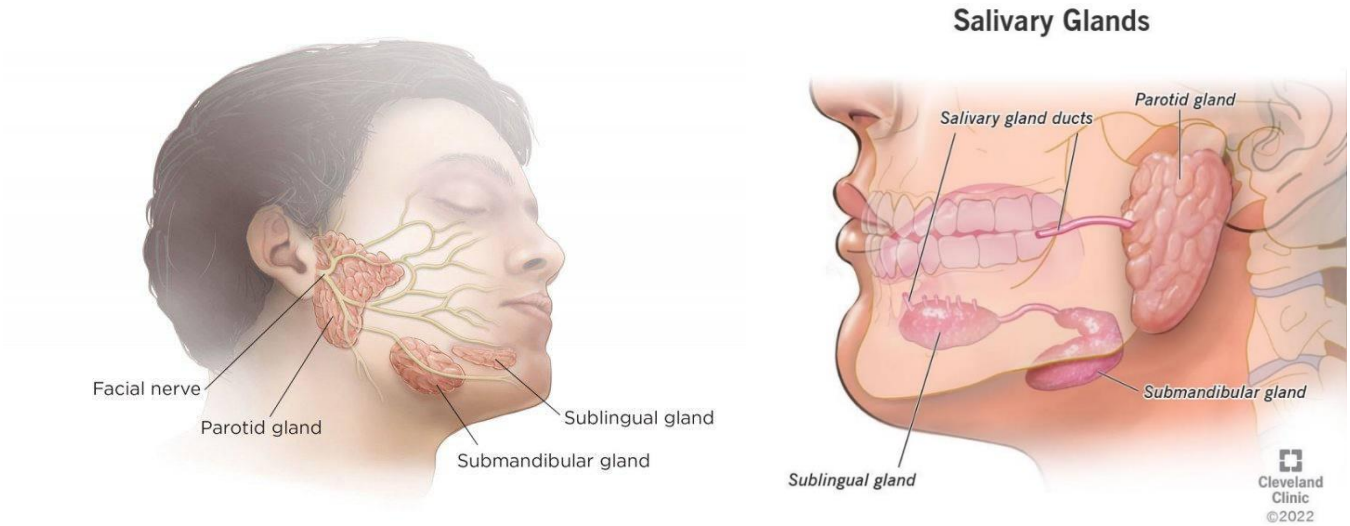

Figure 1 Anatomy of Salivary Glands {1}.

The World Health Organization reported that 23.6% of the global adult population (aged ≥15 years) were current tobacco users in 2018, down from 33.3% in 2000 and projected to decline further to 20.9% by 2025. In the United States in 2018, while an estimated 20% of US adults currently used any tobacco product, 13.7% of US adults (34.2 million people) were current cigarette smokers. From 1965 to 2017, the prevalence of current

smoking declined from 52.0% to 15.8% (relative percent change: 69.6%) among men and from 34.1% to 12.2% (relative percent change: 64.2%) among women.{5}{23}

Smoked tobacco, and in particular, cigarette smoking, is the most popular method of using tobacco. Smoked tobacco is the most common method for nicotine delivery. Smoked tobacco is available in various forms, such as cigarettes, cigars, pipes, bidis, hookah, and others. According to the American Lung Association, a burning cigarette produces more than 7000 chemicals, of which 69 are carcinogens {6}. While each cigarette contains 10–14 mg of nicotine, 1–1.5 mg is absorbed into the body when smoked. Tobacco addiction is driven by nicotine, which is the primary reinforcing component of tobacco. Nicotine is generally delivered through the skin, lungs, and mucous membranes. In addition to associations between tobacco product use and many diseases, cigarettes, smokeless tobacco (e.g. chewing tobacco and snus), and other tobacco uses cause specific oral health issues such as oral cancer, oral mucosal lesions, periodontal disease, implant failure, salivary gland hypofunction, dental caries among many other oral diseases and conditions. A strong association has been found between tobacco use and mucosal lesions such as leukoplakia, smokeless tobacco keratosis at the site of tobacco placement, nicotinic stomatitis, smoker's melanosis and erythrolein{7}{20}.

Periodontal disease is a preventable disease in which tobacco use is considered the strongest modifiable risk factor. Smokers have higher gingival recession, tooth loss, and pocket depths. compared to non-smokers. Tobacco smokers display an increased gingival microvascular density with considerable gingival inflammation, suppressed angiogenesis due to local immune suppression, and oxidative stress leading to periodontal disease and increased risk of complications. The concept of orthodontic treatment is based on applying optimal forces to teeth through fixed orthodontic attachments or removable appliances. The success of the treatment is based on many factors that include maintaining the fixed orthodontic attachments bonded to the enamel of the teeth to be moved {8}{19}. The SBS (shear bond strength) between the resin in

the enamel and the bracket base is influenced by exposure to the oral environment. Smoking is a prevalent habit with approximately 1 billion smokers all over the world. The components of ordinary tobacco smoke is fairly described in the literature owing to the extensive research and developments in analytical techniques. Main stream tobacco smoke is the smoke coming out of the burning tip facing the oral cavity and it is a dynamic aerosol containing up to 5600 chemical components released in the form of mixed gases. Lead and cadmium are concentrated in the enamel of teeth exposed to cigarette smoke causing the development of surface roughness, hardness and discoloration Furthermore, high temperatures might alter the properties of adhesive resin resin. Consequently, smoking can disturb the chemical and mechanical interface between composite resin and enamel .To enable clear understanding of the cigarette smoke effect on a certain structure, a whole smoke exposure system was introduced and utilized in several in vitro studies. Using a whole smoke exposure system enables the investigator to analyses all phases of smoke which is beneficial to identify the exact effect of each phase. An example of commercially available exposure chambers includes those sup- plied by British American Tobacco (Cur bridge Engineering, Hampshire, UK).

Among other effects, it has been observed that nicotine upregulates the formation and differentiation of osteoclasts or osteoclast-like cells and inhibits osteogenesis, callus formation and bone mineralization leading to decreases in bone density. In the oral cavity, smoking has been reported to affect adversely alveolar bone height and density and is considered to be a potential risk factor for alveolar bone loss{9}{22}.

that additional loss of periodontal bone might be expected during orthodontic treatment in smokers.

As orthodontic tooth movement involves bone resorption and formation in the alveolar processes, it may be affected by any substance implicated in the related pathways .Nicotine has been shown to affect bone cells and metabolism .hence, the rate of tooth movement in orthodontic patients, who happen to be nicotine dependent, could be influenced as well.

Chapter Two

Material and Method

MATERIAL AND METHODS

STUDY DESIGN AND POPULATION

This was a cross-sectional questionnaire-based survey study that was carried out from November 2023 to March 2024. The questionnaire was distributed among participants in randomly selected coffee shops and clubs in Al Hilla city.

Inclusion criteria:

- Age ≥ 18 years,
- Both sexes,
- Non-alcoholic
- No history of systemic conditions such as thyroid disease, diabetes mellitus, or renal disease
- No salivary gland disease
- For vapers, the vape juice should contain nicotine
- individuals using one smoking method, i.e., cigarette smoking or vaping only, together with never-smokers (control).

Exclusion criteria:

- Mouth-breathers
- Elderly people (age ≥ 65 years)
- Medication causing xerostomia as a side-effect e.g., diuretics, antihypertensive, antihistamine, and antidepressants
- Patients currently under chemotherapy or radiotherapy
- Not willing to participate
- Individuals using multiple smoking methods simultaneously
- Former smokers

QUESTIONNAIRE'S ELEMENTS AND SCORING

The questionnaire consisted of three parts. The first one was dedicated to collection of information regarding age, history of systemic disease/condition, use of any medication, employment status, and educational level. The second part consisted of questions about smoking method, reason for using/switching to vaping duration and frequency of smoking. The last part comprised 9 questions and the response was based on 5-point Likert scale, namely

“Never”, “Hardly ever”, “Occasionally”, “Fairly often”, “Very often”. The latter responses were given scores 1, 2, 3, 4, 5 respectively. The xerostomia sensation was determined by asking the participants these particular questions about xerostomia. Table 2 shows the interpretation of xerostomia score according to XI xerostomia score. The total scores of all questions, for each participant, were summed and used later for the analysis. The questionnaire was translated into Arabic and was administered to all individuals. Enough time was given for the participants to complete the forms before they were re-collected. Components of the questionnaire used in this study are illustrated in Table 1.

SAMPLE SIZE

The targeted population comprised resident people of Al-Hilla city. According to the latest available statistics, the population of this city is 2,065,042. Sample size was calculated according to the following formula: n= z2 P (1 − P)/d2, where n is the sample size, z (confidence interval at 95%) = 1.96, P (expected prevalence) = 0.5, d (error margin) = 0.05. True sample size then was calculated according to the following formula: True sample = (sample size × population)/ /(sample size + population – 1). Accordingly, the calculated sample size is 384. This number was rounded to 500 and multiplied by 2 to avoid possible drop out of the participants. Therefore, a total of 1000 questionnaires were required to be distributed among eligible participants.

Table 1 Components of the questionnaire

Age: ..... Gender: ☐ Male ☐ Female
Do you have any systemic condition(s)? If yes, please name it/them: .....
Are you chronically using any medication(s)? If yes, please name it/them: .....
Have you received or are you currently under chemotherapy or radiotherapy? ☐ Yes ☐ No
Are you a former smoker? ☐ Yes ☐ No
Do you consume alcohol? ☐ Yes ☐ No
Do you have any respiratory problem that interferes with/obstructs the normal breathing e.g., enlarged adenoids, nasal septum deviation, asthma? ☐ Yes ☐ No
Do you habitually breath from your mouth? ☐ Yes ☐ No
Are you employed? ☐ Yes ☐ No
Specify your educational level: ☐ Postgraduate ☐ bachelor's degree ☐ High school or below
If you are a smoker, at which age did you start smoking? .....
If you are a vaper, is the vape juice supplemented with nicotine? ☐ Yes ☐ No
Which of the following is your main reason for using/switching to vaping? ☐ Less harmful ☐ For smoking cessation ☐ For indoor use ☐ It is easy to obtain ☐ It tastes better ☐ It does not smell like tobacco ☐ Curiosity
Please specify your main smoking type ☐ Cigarettes ☐ Vaping ☐ More than one type ☐ Never smoker
How many cigarettes have you smoked a day on average in the past 30 days? ☐ 1/day ☐ 2-5/day ☐ 6-9/day ☐ 10-19/day ☐ 20 or more/day ☐ Prefer not to say
During the past 30 days, how many days have you vaped? ☐1-2 days/month ☐ 3-5 days/month ☐ 6-9 days/month ☐ 10-19 days/month ☐ > 20 days/month ☐ Prefer not to say
My mouth feels dry ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I have difficulty in eating dry foods ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I have difficulty in eating dry foods ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I get up at night to drink ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
My mouth feels dry when eating a meal ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I sip liquids to aid in swallowing food ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I suck sweets or cough drops to relieve a dry mouth ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
I have difficulties swallowing certain foods ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
The skin of my face feels dry ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often
My lips feel dry ☐ Never ☐ Hardly ever ☐ Occasionally ☐ Fairly often ☐ Very often

Table 2 interpretation of xerostomia score according to XI xerostomia score

Hyposalivation	39
Low salivation	25
Normal salivation	22.5
High salivation	28

Statistical Analysis

The data were statistically analyzed using computer-based software (SPSS, Version 22 for Windows, IBM, Armonk, NY, USA). Mean, standard deviation, and percent were used as descriptive statistics. Inferential analysis was performed for categorical variables. Continuous variables were analyzed by ANOVA test for parametric data while Mann-Whitney and Kruskal-Wallis tests were used for non-parametric data. Statistical significance was considered when the p-value was less than 0.001 at the 95% confidence level

Chapter Three

Result

Result

A total of 851 individuals were invited to participate in the present study. The participants were classified according to different demographic and smoking characteristics (Table 1). Significant differences were observed among cigarette smoker and vaper groups in relation to different variables including age, employment status, and educational level (Table 2).

Table 1: Demographic characteristics and details of the study population

Age, mean ± SD (years)ǂ	**31.27 ±13.89**
Sex, n (%)	
Male	851 (100)
Employment status, n (%)	
Employed	307 (36.08)
Unemployed	551 (64.75)
Educational level,n (%)	
Postgraduate	102 (11.99)
Bachelor's degree	390 (45.83)
High school and below	378 (44.42)

The mean score in the cigarette smoker group was significantly higher ($p < 0.001$) than in vaper groups, (Table 3). Subgroup analysis according to different independent variables showed that no significant differences were observed in cigarette smokers expect for educational level where scores of "High school and below" were significantly higher than the other two subclasses (Table 3). Table 4 shows a significant difference in xerostomia scores among groups according to different independent variables

Table2 Analysis of demographic characteristics and details of the study population according to smoking/vaping methods

Variables	Cigarette	Vaping	*p*- value*
Age, mean ± SD (years)ǂ	34.18± 14.59	24.80 ± 8.30	**< 0.001**
Age range, median (years)	34	23	
Sex, *n* (%)			
Male	596 (70.03)	255 (29.96)	**< 0.001**
Employment status, *n* (%)			
Employed	210 (24.67)	96 (11.28)	**< 0.001**
Unemployed	371 (43.59)	175 (20.56)	**< 0.001**
Educational level, *n* (%)			
Postgraduate	65 (7.63)	37 (4.34)	**< 0.001**
Bachelor's degree	238(27.96)	150 (17.62)	**< 0.001**
High school and below	283 (33.25)	97 (11.39)	**< 0.001**

*Significance level at $p < 0.05$ by ANOVA– t-test

Table 3 Comparison of xerostomia scores among groups according to different independent variables

Variables	Cigarettes	Vaping	P-value*
Smoking method	**22.03 ± 8.18**	**18.80 ± 7.49**	**0.001**
Employed	**22.43 ± 9.35**	**18.33 ± 7.76**	**0.001**
Unemployed	**22.33 ± 4.9**	**18.15 ± 5.8**	**0.001**
Educaional level			
Postgraduate	**20.04 ± 5.61**	**17.90 ± 4.29**	**0.001**
Bachelor's degree	**19.3 ± 4.82**	**16.2 ± 3.79**	**0.001**
High school and below	**23.95 ± 4.25**	**19.83 ± 5.97**	**0.001**

*Significance level at $p < 0.05$, Kruskal-Wallis and Mann-Whitney test

Chapter Five

Discussion

The present cross-sectional study investigated the association between self-reported xerostomia symptoms and vaping as well as cigarette smoking behaviors. A total of 851 individuals were invited to participate in the present study{11}{16}. The participants were classified according to different demographic and smoking characteristics. The result showing that 596 person (70 percentage) are using usual smoking, and 255 (29 percentage) are using vaping. These ratios reflect several reasons to give the upper hand for smoking. The findings feature the multifaceted nature of these associations, influenced by various demographic factors such as age, employment status, and educational level{12}{17}.

Age Differences

The study revealed significant age differences between cigarette smokers and vapers, with cigarette smokers being notably older than vapers. This disparity was reflected in the mean age of initiation, which was higher among cigarette smokers compared to vapers{13}{18}. These findings suggest distinct preferences for smoking and vaping across different age groups, with vaping being more prevalent among younger individuals. The result can be explained by the following:

- Older Age of Cigarette Smokers: Older individuals may have been smoking cigarettes for a longer duration, leading to higher prevalence rates among this demographic.
- Younger Age of Vapers: Younger individuals may be more inclined to experiment with newer technologies and trends, such as vaping, contributing to higher prevalence rates among this demographic.

Employment Status and Educational level

Employment status and educational level emerged as significant factors influencing smoking and vaping behaviors. Employed individuals were more likely to smoke cigarettes compared to vapers, while a higher proportion of unemployed individuals engaged in both smoking and vaping. Similarly, individuals with lower educational attainment reported higher rates of smoking and vaping compared to those with higher educational levels {9}{15}. These findings suggest a complex interplay between socioeconomic status, stress levels, and access to cessation resources in shaping tobacco and nicotine use behaviors. The result can be explained by the following:

- Employed individuals may face higher stress levels in the workplace, leading to higher rates of cigarette smoking as a coping mechanism.

- Unemployed individuals may experience boredom or lack of structured activities, increasing the likelihood of engaging in both smoking and vaping.
- Lower educational attainment may be associated with lower awareness of the health risks of smoking and vaping, leading to higher prevalence rates among this demographic.
- Higher educational attainment may provide individuals with greater access to information and resources for smoking cessation, resulting in lower prevalence rates among this demographic.

Impact on Xerostomia Symptoms

The study explored the impact of smoking method, employment status, and educational level on xerostomia symptoms. Both smoking and vaping were associated with xerostomia symptoms, with variations observed based on smoking method, employment status, and educational level. Notably, employed individuals reported higher rates of xerostomia symptoms compared to the unemployed, potentially reflecting the impact of occupational stress on oral health outcomes{24}{25}.

- Smoking and Vaping: Both smoking and vaping can contribute to xerostomia symptoms due to the drying effect of nicotine and other chemicals on saliva production {16}.
- Employment Status: Employed individuals may experience higher levels of stress, which can exacerbate xerostomia symptoms.
- Educational Level: Lower educational attainment may be associated with poorer oral health knowledge and behaviors, leading to higher rates of xerostomia symptoms among this demographic {10}{15}.

Study impact on orthodontic treatment

The findings of this study underscore the significant implications of self-reported xerostomia symptoms, often exacerbated by smoking and vaping behaviors, on orthodontic treatment outcomes. Xerostomia poses challenges to orthodontic health by increasing the risk of dental complications such as caries and periodontal disease, complicating oral hygiene maintenance, and potentially prolonging treatment duration. Orthodontists play a pivotal role in educating patients about the importance of oral hygiene and the risks associated with tobacco and nicotine use, collaborating with other dental professionals to monitor and manage oral health during treatment. By addressing xerostomia symptoms and their underlying causes, orthodontists can optimize treatment outcomes and ensure the long-term oral health and well-being of their patients.

Limitations of the study include potential selection bias due to non-random recruitment, which may lead to an overrepresentation of certain demographic groups. Additionally, reliance on self-reported

data for smoking/vaping behaviors and xerostomia symptoms may introduce recall and social desirability biases, impacting the accuracy and generalizability of the findings. The cross-sectional design limits the ability to establish causality between smoking/vaping behaviors, xerostomia symptoms, and orthodontic health outcomes, highlighting the need for longitudinal studies with objective measures. These limitations underscore the importance of interpreting the study findings cautiously and conducting further research to validate the observed associations.

Conclusion & Suggestion

1. The study identified significant demographic disparities in smoking and vaping behaviors, with age, gender, employment status, and educational level playing crucial roles in shaping tobacco and nicotine use patterns.
2. Cigarette smokers tended to be older than vapers, indicating distinct preferences for smoking and vaping across different age groups. Additionally, vapers tended to initiate electronic device use at a younger age compared to cigarette smokers.
3. Employed individuals were more likely to smoke cigarettes compared to vapers, while a higher proportion of unemployed individuals engaged in both smoking and vaping. Lower educational attainment was associated with higher rates of smoking and vaping.
4. Both smoking and vaping were associated with xerostomia symptoms, with variations observed based on smoking method, employment status, and educational level. Employed individuals reported higher rates of xerostomia symptoms compared to the unemployed.

Suggestions for Future Research

1. Conduct longitudinal studies to examine the temporal relationship between smoking/vaping behaviors and xerostomia symptoms, allowing for a better understanding of causality.
2. Investigate the underlying biological mechanisms linking smoking/vaping to xerostomia symptoms, including the effects on salivary gland function and oral microbiota.
3. Implement and evaluate targeted interventions aimed at reducing tobacco and nicotine use prevalence rates and improving oral health outcomes among diverse population groups.
4. Assess the impact of tobacco control policies and regulations on smoking and vaping behaviors, as well as their effects on xerostomia symptoms and other oral health indicators.

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