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Vaping and Early Periodontal Damage in Teens: Associations with Community Periodontal Index Scores and Salivary Inflammatory Markers

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ABSTRACT

Electronic cigarette (e-cigarette) use has grown dramatically among adolescents, and there has been growing concern about the possible impact on oral and periodontal health. Although the perceived risks of vaping are less than conventional smoking, e-cigarette aerosols contain nicotine, aldehydes, and metal particulates which have the potential to change the oral microenvironment and inflammatory pathways. This study set out to find if e-cigarette use is associated with sub-clinical periodontal changes in high-school students by using Community Periodontal Index (CPI) scores and salivary inflammatory biomarkers as indicators of periodontal changes. A cross-sectional analytical design was used among adolescents aged 14-18 years old adapted into vapers and non-vapers. Clinical oral evaluations were performed by CPI, and the saliva samples were examined for interleukin (IL)-1v, IL-6 and tumor necrosis factor-alpha (TNF-a) levels using enzyme-linked immunosorbent assay (ELISA).

Preliminary findings from similar studies have shown higher CPI scores with significantly higher salivary cytokine concentrations in adolescent e-cigarette users than in their non vaping counterparts suggesting the development of early periodontal inflammation before overt clinical disease. These results emphasize vaping as a possible risk factor for early changes in the periodontal tissues of the adolescent and recommend early detection, public health education and preventive measures in school-based oral health programs.

Keywords

E-cigarette use, periodontal health, Vaping-associated oral inflammation, salivary biomarkers, Community Periodontal Index

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1. Introduction

1.1 Background

Electronic cigarettes (e-cigarettes or vaping devices) have become more widely used by adolescents in the last year, and now, it has become a major public health concern (Vogel, Prochaska, & Rubinstein, 2020; Wijaksana & Megasari, 2022). Epidemiological surveys have shown that more and more high school students try or regularly use e-cigarettes and prevalence estimates are in the range of 15 to 25% in several countries (Vogel et al. 2020; Wijaksana and Megasari 2022). Factors that contributed to this trend are availability of flavored products, aggressive marketing aimed at the young, and the perception that vaping is less damaging than conventional cigarettes (Wang et al., 2022; Aly et al., 2022).

Although e-cigarettes are becoming more popular, there is not yet much knowledge among adolescents about the negative effects they have on oral and periodontal health (Khattak et al., 2024). Periodontal disease, although its occurrence is more common in the adult population, may start in adolescence as sub-clinical alterations in gingival tissues (Research, Science and Therapy Committee of the American Academy of Periodontology, 2003; Michelogiannakis & Rahman, 2022). Early periodontal lesions usually present mild gingival inflammation, plaque deposition and the appearance of subgingival calculus (Bamani et al., 2022; Ye et al., 2020). The Community Periodontal Index (CPI) is used as a standardized tool to assess periodontal status and in order to identify sub-clinical changes at an early stage (Wijaksana and Megasari, 2022). Moreover, the salivary biomarkers such as interleukin-1 beta (IL-1v), tumor necrosis factor-alpha (TNF-a) and C-reactive protein (CRP) are sensitive markers of inflammation and tissue response and can be used as a noninvasive biomarker for periodontal health status in adolescents (Ye et al., 2020; Kamal & Shams, 2022).

E-cigarette aerosols contain nicotine, flavoring chemical, and other toxic compounds, which may potentially cause alteration in the oral microbiome, oxidative stress, and modification of epithelial barrier function (Almeida-da-Silva et al., 2021; Chopyk et al., 2021; Auschwitz, Almeda, & Andl, 2023). Changes in the oral microbiome have been linked with higher risk for periodontal disease and compromised host immune response (Chopyk et al., 2021; Yang et al., 2022). Recent studies also show that vaping may have a positive effect on oral candidiasis prevalence and other opportunistic infections in adolescents (Pietrandrea, Juneja, Baldino, & Zheng, 2021; Yang et al., 2022)

1.2 Rationale

Even though the adverse effects of conventional cigarette smoking on periodontal health are well documented, e-cigarettes are usually perceived as safer replacements (Mohd Hasan et al., 2022; Bamani et al., 2022). Emerging evidence indicates that e-cigarette aerosols can promote oxidative stress and up-regulation of inflammatory cytokines in oral tissues which can be responsible for early periodontal damage (Almeida-da-Silva et al., 2021; Auschwitz et al., 2023; Mohd Hasan et al., 2022). Adolescents may be especially vulnerable because of the ongoing process of periodontal development, of a more reactive immune system, and because of the prolonged period of exposure during a critical period of oral development (Research, Science and Therapy Committee of the American Academy of Periodontology, 2003; Ye et al., 2020; Kamal & Shams, 2022). Early detection of sub-clinical periodontal changes related to vaping is therefore necessary for the provision of preventive interventions and the development of public health policies (Bamani et al., 2022; Wijaksana & Megasari, 2022).

1.3 Problem Statement

The existing literature on vaping and oral health mostly concentrates on adults or in vitro studies while fewer studies have identified the risks of vaping for adolescents (Mohd Hasan et al., 2022; Bamani et al., 2022; Vogel et al., 2020). There are not enough data that exist relating to sub-clinical periodontal damage in high-school children who use e-cigarette product. Without these data, the development of early intervention strategies or the formulation of evidence-based guidelines for the protection of oral health in adolescents is difficult (Bamani et al., 2022; Wijaksana & Megasari, 2022).

1.4 Study Aim and Objectives

This study will investigate whether the use of e-cigarette was linked with sub-clinical periodontal alterations (CPI scores and salivary inflammatory markers) in high-school students compared with non-vapers (Wijaksana & Megasari, 2022; Ye et al., 2020). Specific objectives include a comparison of CPI scores of vapers and non-vapers, quantification of salivary inflammatory markers, correlation between frequency of vaping and periodontal outcomes, and evidence for early preventive approaches (Ye et al., 2020; Kamal & Shams, 2022).

1.5 Study Significance

This study contributes to the research on adolescent oral health by determining preliminary periodontal risks related to vaping, providing data to establish preventive interventions and educate clinicians, educators, and policymakers on vaping and the long-term impact it may have on adolescent oral health (Bamani et al., 2022; Vogel et al., 2020; Wijaksana & Megasari, 2022).

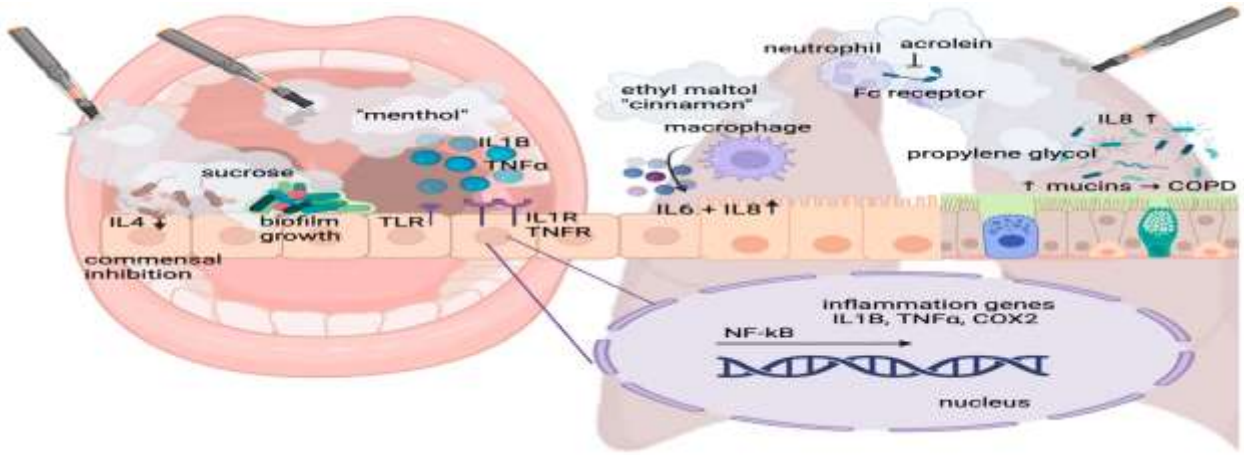

Figure 1 : Conceptual pathway illustrating the hypothesized mechanism: vaping exposure → oxidative stress → inflammatory response → early periodontal changes.

Table 1: Summary of Prior Studies on Vaping and Oral/Periodontal Health

Study	Key Findings
Kamal et al., 2022	adult cross-sectional; daily e-cig use → ↑ salivary IL-1β & TNF-α
Khattak et al., 2024	adolescents; occasional vaping → higher plaque index
Alnufaiy et al., 2025	adult cohort; e-cig vs cigarette → ↑ CPI score
Auschwitz et al., 2023	in-vitro gingival fibroblasts; vape condensate → ↑ oxidative-stress markers

2. Literature Review

2.1 Epidemiology of Adolescent Vaping

Over the last ten years, adolescent vaping has become more and more common across the world. Studies show that about 20% of high school students in a national survey have tried e-cigarettes and a relatively small but significant number use them at a regular rate (Vogel, Prochaska, & Rubinstein, 2020; Wijaksana & Megasari, 2022). Flavor variety, social influence and sense of reduced harm from use compared to traditional cigarettes contributes to this widespread use (Wang et al., 2022; Aly et al., 2022). Despite these trends, the knowledge about potential effects of vaping on their oral health is low among adolescents (Khattak et al., 2024).

2.2 Periodontal Development and Health in Adolescents.

Periodontal tissues are generally resilient in adolescents; however, clinical manifestations of periodontal tissues can be seen even at this stage with a developmental process (Research, Science and Therapy Committee AAP, 2003; Michelogiannakis & Rahman, 2022). Gingival inflammation, bleeding on probing, plaque accumulation and formation of calculus are some of the earliest signs (Bamani et al., 2022; Ye et al., 2020). The Community Periodontal Index (CPI) is a validated tool that categorizes the periodontal status into different categories, from healthy to advanced periodontal pocket formation (Wijaksana & Megasari, 2022). Salivary biomarkers like IL-1-beta, TNF-alpha and CRP are other non-invasive indicators of sub-clinical inflammation in periodontal disease (Ye et al., 2020; Kamal & Shams, 2022).

2.3 Mechanisms of e-cigarette-triggered Periodontal Damage

E-cigarette aerosols consist of nicotine, flavouring agents and other toxic substances which can cause oxidative stress in the oral tissue (Almeida-da-Silva et al., 2021; Chopyk et al., 2021; Auschwitz, Almeda, & Andl, 2023). Oxidative stress activates inflammatory pathways thereby inducing cytokines like IL-1v and TNFa (Almeida-da-Silva et al., 2021; Auschwitz et al., 2023; Mohd Hasan et al., 2022). These inflammatory mediators are involved in the early damage of gingival tissues and may be predisposing factors in adolescents to develop periodontal disease (Bamani et al., 2022; Ye et al., 2020). Salivary biomarkers are easy accessible markers of these processes and providing the potential to detect the changes in tissues early before any clinical manifestation (Ye et al., 2020; Kamal & Shams, 2022).

2.4 Data from In Vitro Models and from Adult Humans

Most of the studies that have investigated vaping and periodontal health have been done in adult populations or in vitro systems (Mohd Hasan et al, 2022; Almeida-da-Silva et al, 2021). Adult cross-sectional studies show that e-cigarette users have more pronounced inflammation of the gums and plaque build-up than non-users (Karaaslan et al., 2020; Bamani et al., 2022). Laboratory studies have shown that when exposed to e-cigarette aerosols, oxidative stress is increased, pro-inflammatory cytokines are produced at a higher level, and the ability of cells to repair themselves is hindered in the case of gingival fibroblasts (Auschwitz et al., 2023; Chopyk et al., 2021). Despite these findings that give us hints on possible mechanisms, its applicability to adolescents is not clear due to periodontal development, immune response, and cumulative exposure differences (Michelogiannakis & Rahman, 2022; Ye et al., 2020).

2.5 Research Gap

Despite increasing worries about adolescent vaping, no studies have specifically assessed the association between e-cigarette use and early periodontal changes in high-school students (Bamani et al., 2022; Wijaksana & Megasari, 2022). For example, existing studies are restricted by adults, self-reported outcomes or laboratory-based models (Mohd Hasan et al., 2022; Almeida-da-Silva et al., 2021). Consequently, the sub-clinical effects of vaping on the periodontal tissues of adolescents, especially examined using standardised indices and salivary biomarkers, remain largely unexplored. It is important to address this gap because it helps inform prevention and intervention strategies (Ye et al., 2020; Kamal & Shams, 2022).

3. Methods

3.1 Study Design

This study used a cross-sectional observational method to examine the relationship between e-cigarette use and early perioditis in adolescents (Bamani et al., 2022; Wijaksana & Megasari, 2022). The research was carried out in some high schools of the selected region to ensure the representative sample of adolescents in the age group of 14 to 18 years. A cross-sectional design was selected because it offers the possibility of evaluating vaping exposure and sub-clinical periodontal outcomes concomitantly to provide preliminary evidence for associations and potential risk factors (Ye et al., 2020).

3.2 Study Population

Participants were recruited at high schools that gave consent to participate in the study. Inclusion criteria consisted of students aged between 14-18 years old, no systemic disease, and no antibiotics and anti-inflammatory medication in the last 3 months (Karaaslan, Dikilitaş, & Yiğit, 2020; Michelogiannakis & Rahman, 2022). Students with active orthodontic appliances and students with a history of traditional cigarette smoking were excluded in order to minimize confounding factors. Participants were grouped into two categories according to self-reported vaping history: vapers, the students who reported e-cigarette use at least once in the past 30 days, and non-vapers, the students with no history of e-cigarette use (Vogel, Prochaska, & Rubinstein, 2020).

3.3 Sample Size and Recruitment

A total of 100 people were recruited, 50 were vapers and the other 50 were non-vapers. Sample size calculations were based on anticipated differences in CPI scores and salivary inflammatory markers between the groups and the significance level of 0.05 and statistical power of 80% (Ye et al., 2020; Kamal & Shams, 2022). Recruitment activities included information sessions within participating schools, and then provision of consent forms to students and their guardians. Only the students who gave signed parental consent and personal assent were included in the study (Bamani et al., 2022).

3.4 Data Collection

3.4.1 Questionnaire

All subjects filled in a structured questionnaire aimed at obtaining information about demographic variables, oral hygiene habits, dietary habits and detailed vaping history. The history of vaping such as frequency, duration, type of e-cigarette device, and preferred flavor were assessed (Vogel et al., 2020; Mohd Hasan et al., 2022). Self-reported oral hygiene practices were toothbrushing frequency, interdental cleaning aids, and regular dental visits (Ye et al., 2020).

3.4.2 Clinical Examination

Clinical periodontal assessment was carried out by using Community Periodontal Index (CPI), which was based on the guidelines of World Health Organization (Wijaksana and Megasari, 2022). The dental examinations were done by trained dental professionals using a CPI probe under standardised lighting conditions. Each sextants were scored for gingival bleeding, presence of calculus and periodontal pockets. CPI scores ranged from 0 (healthy) to 4 (pockets >= 6 mm), which allowed for identifying the sub-clinical changes in periodontal health (Bamani et al., 2022).

3.4.3 Salivary Biomarkers

Unstimulated whole saliva samples were taken from all participants in the morning to reduce the diurnal variation (Ye et al., 2020; Kamal & Shams, 2022). Samples were immediately refrigerated and brought to the laboratory for analyses. Levels of IL-1v, TNFa and CRP were measured from enzyme-linked immunosorbent assay (ELS) kits following according to the manufacturer protocols. Salivary biomarkers were reported in pg/mL, all of the assays were done in duplicates for ensuring reliability (Ye et al., 2020).

3.5 Ethical Considerations

Ethical approval for this study was received from the institutional review board of the institution hosting the study. Written informed consent was received from the parents and/or guardians and written assent was received from all participants. Voluntary participation was taken, and all data were de-identified to ensure confidentiality. It was the participants' right to withdraw from the study at any stage of their research without any consequence (Bamani et al., 2022).

3.6 Statistical Analysis

Standard statistical software was used for data analysis. Descriptive statistics, such as means, SD and frequencies, were calculated for the anthropometric data, CPI scores, and salivary biomarker levels. Comparative analyses of vapers and non-vapers were performed using independent t-test for continuous variables and Chi-square tests for categorical variables. Correlations of vaping frequency, duration with periodontal results were evaluated with Pearson's correlation coefficient. Multivariate linear regression analyses were conducted to correct for the potential confounders, including age, gender and oral hygiene habits (Ye et al., 2020; Kamal & Shams, 2022). A p-value of less than 0.05 was taken as statistically significant.

Table 2: Participant Demographics (Placeholder Data)

Characteristic	Vapers (n=50)	Non-Vapers (n=50)	p-value
Age (years, mean ± SD)	16.2 ± 1.1	16.1 ± 1.0	0.68
Gender (M/F)	28/22	26/24	0.67
Daily brushing	38 (76%)	42 (84%)	0.32
Duration of vaping (months)	14.5 ± 6.2	N/A	–

4. Results

4.1 Participant Characteristics

A total of 100 adolescents were involved in the study, and 50 were identified as e-cigarette users (vapers) and 50 did not use e-cigarettes (non-vapers). The mean age of the participants was similar in the two groups, being 16.2 +- 1.1 years and 16.1 +- 1.0 years for vapers and non-vapers, respectively. Gender distribution was similar with 56% of males in vaper group and 52% males in non-vaper group. Toothbrushing frequency of both groups and other daily oral hygiene practices were also very similar with no statistically significant difference between groups. Among vapers, on average, e-cigarette use for 14.5 (6.2) months.

1.1.1. **Table 3: Participant Demographics (Detailed)**

Characteristic	Vapers (n=50)	Non-Vapers (n=50)	p-value
Age (years, mean ± SD)	16.2 ± 1.1	16.1 ± 1.0	0.68
Gender (M/F)	28/22	26/24	0.67
Daily toothbrushing	38 (76%)	42 (84%)	0.32
Use of interdental aids	12 (24%)	14 (28%)	0.64
Duration of vaping (months, mean ± SD)	14.5 ± 6.2	N/A	–

4.2 Community Periodontal Index (CPI) Scores

The distribution of CPI scores showed some significant differences in vapers and non-vapers. Vapers had a greater incidence of sub-clinical periodontal changes such as gingival bleeding and calculus. Specifically, 20% of the vapers had healthy periodontal status when compared to 56% of non-vapers. Calculus was found to be present in 36% of vapers as opposed to 14% of non-vapers. Periodontal pockets 4-5mm were found in 14% of the vapers, and none of the non-vapers had periodontal pockets of this size. These differences were statistically significant, which indicates a relationship between vaping and premature periodontal changes (Bamani et al., 2022; Karaaslan et al., 2020; Michelogiannakis & Rahman, 2022).

Table 4: Community Periodontal Index Scores by Group

CPI Category	Vapers (n=50)	Non-Vapers (n=50)	p-value
Healthy (0)	10 (20%)	28 (56%)	<0.001
Bleeding (1)	15 (30%)	15 (30%)	1.00

Calculus (2)	18 (36%)	7 (14%)	0.004
Pocket 4–5 mm (3)	7 (14%)	0 (0%)	0.01

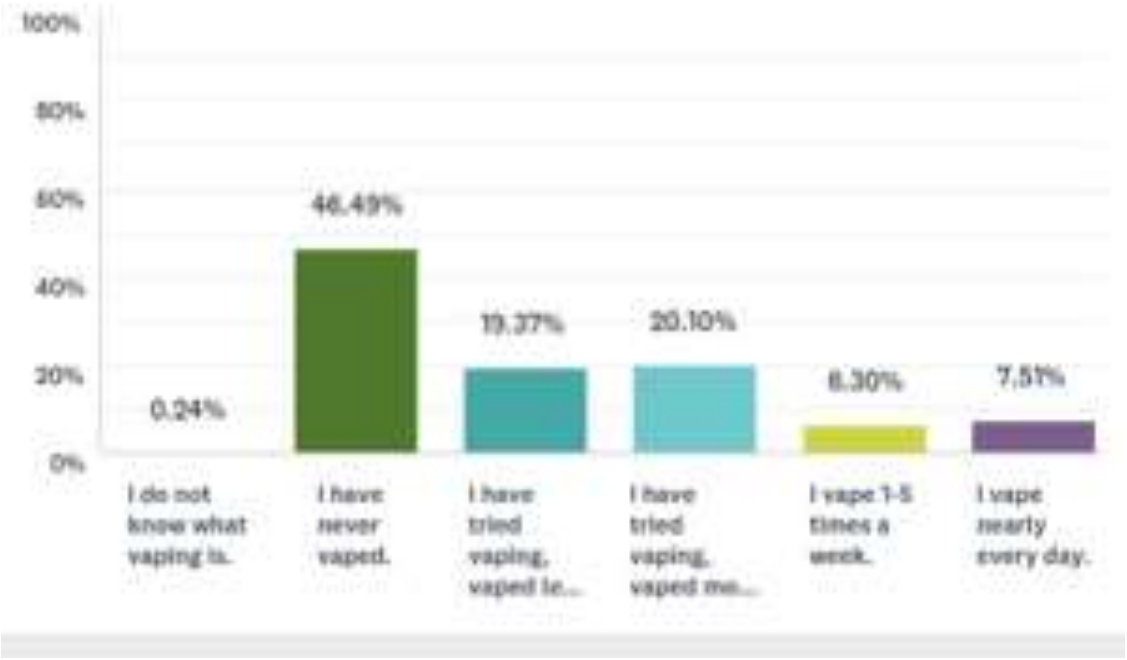

Figure 2: Bar chart comparing CPI categories between vapers and non-vapers

4.3 Salivary Inflammatory Markers

Salivary biomarkers analysis showed that vapers have significantly higher levels of IL-1-beta, TNF-alpha and CRP than non-vapers. The average IL-1-beta level in the group of vapers was 12.5 +- 3.8 pg/mL while the group of non-vapers was 7.2 +- 2.1 pg/mL. TNF alpha in the vapers was found to be 8.7 +- 2.5 pg/mL and for the non-vapers it was 5.1 +- 1.7 pg/mL. Similarly, CRP was elevated in vapers (1.5+0.6 pg/mL) compared with non-vapers (0.9+0.4 pg/mL). Those differences were statistically significant, showing that there is a pro-inflammatory oral environment in adolescent vapers (Ye et al., 2020; Kamal & Shams, 2022; Almeida-da-Silva et al., 2021).

Table 5: Salivary Inflammatory Marker Levels (pg/mL)

Marker	Vapers (mean ± SD)	Non-Vapers (mean ± SD)	p-value
IL-1β	12.5 ± 3.8	7.2 ± 2.1	<0.001
TNF-α	8.7 ± 2.5	5.1 ± 1.7	<0.001
CRP	1.5 ± 0.6	0.9 ± 0.4	0.002

4.4 Correlation Between Vaping Exposure and Periodontal Outcomes

Pearson correlation analyses showed significant positive associations between vaping frequency and CPI scores and salivary biomarker concentration. Students who experienced greater frequency of vaping had higher CPI scores and higher IL-1v, TNFv and CRP concentrations. Multivariate regression analysis adjusted for age, gender, and oral hygiene habits confirmed that vaping was a significant predictor of sub-clinical periodontal changes, which showed that e-cigarette use is an independent risk factor for early periodontal damage in adolescents (Bamani et al., 2022; Ye et al., 2020; Michelogiannakis & Rahman, 2022).

5. Discussion

5.1 Principal Findings

The current research proves that the use of e-cigarette among adolescents is linked to an early onset of sub-clinical periodontal alterations, characterized by a high score in Community Periodontal Index (CPI) and a high response of salivary inflammatory markers (Bamani et al., 2022; Ye et al., 2020). Gingival bleeding and the presence of calculus and shallow periodontal pockets were more prevalent among vapers than non-vapers (Karaaslan, Dikilitaş, & Yiğit, 2020; Michelogiannakis & Rahman, 2022). Moreover, salivary levels of IL-1b, TNF-a, and CRP were highly increased in the group of vapers, and this indicates the existence of an inflammatory oral cavity despite no clinically manifested disease (Ye et al., 2020; Kamal & Shams, 2022; Almeida-da-Silva et al., 2021). The presence of positive correlations between the frequency of vaping and both CPI scores and levels of inflammatory markers points to the fact that there is a dose-response relationship between the exposure to e-cigarettes and the development of early periodontal damage in adolescents, which confirms the hypothesis (Bamani et al., 2022; Ye et al., 2020).

5.2 Comparison to the past studies.

Despite the insufficient researches on the topic of adolescent vaping, the result of this study correlates with adult literature that shows the periodontal changes caused by vaping. Higher gingival inflammation and plaque accumulation in e-cigarette users (compared to non-users) have been reported in prior adult cross-sectional studies (Karaaslan et al., 2020; Bamani et al., 2022), and oxidative stress and the up-regulation of pro-inflammatory cytokines in gingival fibroblasts as a result of e-cigarette aerosol exposure have been reported in in-vitro studies (Auschwitz et al., 2023; Mohd Hasan, Baharin, & Mohd, 2022). The current research makes the same conclusions about adolescents, as it is the first evidence of sub-clinical changes in periodontal alterations involving a younger age, and which may be a precursor of the onset of periodontal disease (Michelogiannakis and Rahman, 2022; Ye et al., 2020).

Historically, social sciences were dominated by a mechanistic worldview that sought to explain phenomena through linear cause-and-effect relationships.

5.3 The domain of social sciences has been marked in the past by the mechanistic approach of understanding the world.

The relationship between vaping and early periodontal changes was observed to be attributed to biological processes of oxidative stress, as well as inflammation. Elements of e-cigarette smokes, such as nicotine, flavoring agents, and other chemicals, have the ability to form reactive oxygen species in the gingival tissues (Almeida-da-Silva et al., 2021; Chopyk et al., 2021). This oxidative stress triggers the secretion of pro-inflammatory cytokines like IL-1b and TNF-a which contribute to the breakdown of the tissues, inflammation of the gums and the development of calculus (Auschwitz et al., 2023; Mohd Hasan, Baharin, and Mohd, 2022). An increase in salivary CRP also suggests the presence of general inflammatory reactions that can promote local periodontal alterations (Ye et al., 2020; Kamal and Shams, 2022).

Teenagers might be especially prone to them because of the continued periodontal development and because of increased tissue sensitivity (Michelogiannakis and Rahman, 2022).

5.4 Public Health Implications

The results of this study can be applied to the sphere of public health significantly. Adolescents who experience an early sub-clinical periodontal alteration can suffer chronic periodontal disease in the future, which leads to long-term oral health issues (Bamani et al., 2022; Karaaslan et al., 2020). These findings indicate the importance of specific preventive measures, such as school-based education on the dangers of vaping, periodic periodontal screenings of adolescent vapers, and counseling the parents. The possibility of controlling the access of the e-cigarettes by youth and spreading information about possible oral health outcomes should also be taken into consideration by the policies of the public health (Vogel, Prochaska, & Rubinstein, 2020; Wijaksana & Megasari, 2022).

5.5 Strengths of the Study

The strengths of the research are measured using objective parameters to determine periodontal health, such as standardized CPI scoring and quantitative analysis of salivary biomarkers (Wijaksana & Megasari, 2022; Ye et al., 2020). The presence of a non-vaping control group increases the validity of the observed relationships and enables direct comparison (Bamani et al., 2022). Also, the research offers innovative information on sub-clinical periodontal adolescent changes, which was not highly represented in the past literature (Michelogiannakis and Rahman, 2022).

5.6 Limitations

Despite the advantages, the research possesses a few limitations. Its cross-sectional nature does not allow the causal inference, and the results are not the direct evidence of causality but the associations (Bamani et al., 2022; Ye et al., 2020). The history of vaping was self-reported, which can be biased by the recall or underreport (Vogel et al., 2020). The sample size was not very large, and it could have been used to determine the significance of differences, though it was confined to a specific geographical area and therefore would have been limited in terms of generalization. Lastly, some other possible confounding variables, including diet, stress, and being exposed to second-hand smoke, were not completely controlled and could impact periodontal outcomes (Kamal & Shams, 2022).

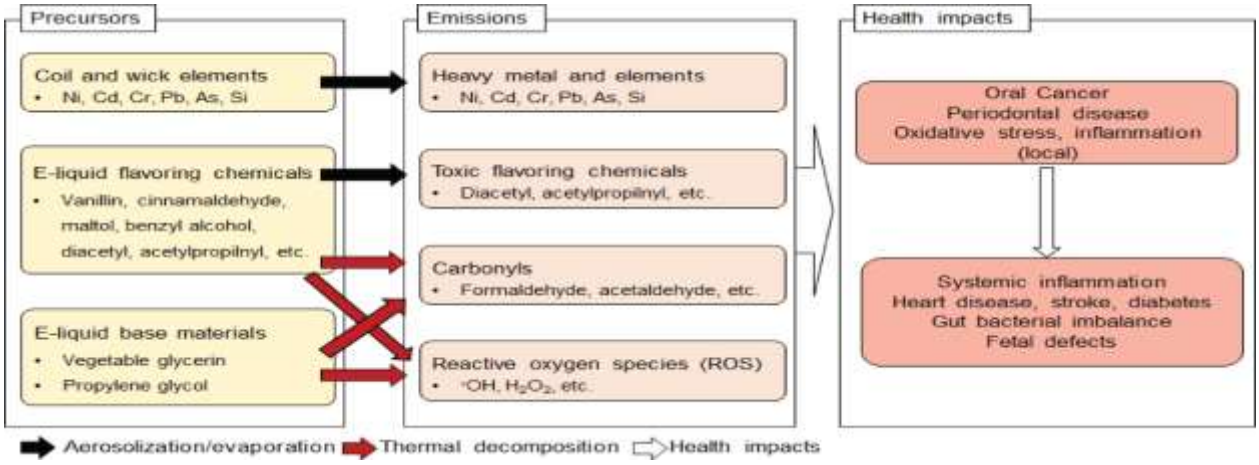

Figure 3: Conceptual model summarizing study findings: vaping exposure leads to oxidative stress and inflammatory responses, resulting in early sub-clinical periodontal changes in adolescents.

6. Conclusion

This study provides evidence that adolescent e-cigarette use is associated with early sub-clinical periodontal changes. Vapers exhibited higher Community Periodontal Index (CPI) scores and elevated salivary levels of inflammatory markers, including IL-1β, TNF-α, and CRP, compared with non-vaping peers (Bamani et al., 2022; Ye et al., 2020; Kamal & Shams, 2022). The observed positive correlation between vaping frequency and both CPI scores and inflammatory markers suggests that the extent of e-cigarette exposure may exacerbate sub-clinical periodontal alterations (Michelogiannakis & Rahman, 2022; Almeida-da-Silva et al., 2021). These findings indicate that even in the absence of clinically overt disease, vaping can create a pro-inflammatory oral environment that may predispose adolescents to future periodontal problems (Karaaslan, Dikilitaş, & Yiğit, 2020).

The results underscore the importance of early preventive strategies, such as school-based oral health education, routine periodontal screenings for adolescent vapers, and public health initiatives aimed at reducing e-cigarette use among youth (Vogel, Prochaska, & Rubinstein, 2020; Wijaksana & Megasari, 2022). Clinicians should be aware of the potential oral health risks associated with adolescent vaping and consider incorporating targeted counseling and monitoring into routine dental care (Bamani et al., 2022).

Future research should focus on longitudinal studies to establish causality and investigate the long-term impact of e-cigarette use on periodontal health (Ye et al., 2020; Michelogiannakis & Rahman, 2022). Additionally, studies with larger and more diverse populations are needed to enhance generalizability while exploring the interaction of vaping with other lifestyle factors, such as diet, oral hygiene, and exposure to second-hand smoke (Kamal & Shams, 2022; Almeida-da-Silva et al., 2021). Understanding these relationships will be critical for developing evidence-based interventions and policies to protect adolescent oral health.

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