COMPARATIVE EVALUATION OF THE HARMFUL EFFECT OF ELECTRONIC NICOTINE DELIVERY SYSTEM AND CONVENTIONAL CIGARETTES ON ORAL HEALTH IN ADOLESCENTS IN DELHI NCR REGION.

Dr. Ritika Malhotra[1*], Dr. Anjali Saini[1], Dr. Pulkit Jhingan[1], Dr. Hau Muan Kim[1], Dr. Sudipa Jana[1], Dr. Anubha Jain[1]

[1]Department of Pediatric and Preventive Dentistry, Inderprastha Dental College & Hospital, Sahibabad, Ghaziabad, Uttar Pradesh 201010, India*

[1]Professor and Head (Dr. Ritika Malhotra) | Professor (Dr. Pulkit Jhingan) | Senior Lecturer (Dr. Anubha Jain) | Post Graduate Student (Dr. Anjali Saini, Dr. Hau Muan Kim, Dr. Sudipa Jana)

[1]Email: Ritikaaahuja@yahoo.com

***Corresponding Author:** Dr. Ritika Malhotra, Professor and Head, Department of Pediatric and Preventive Dentistry, Inderprastha Dental College & Hospital, Sahibabad, Ghaziabad, Uttar Pradesh 201010, India | Email: Ritikaaahuja@yahoo.com

ABSTRACT

Introduction:

E-cigarette aerosols promote oral inflammation and disturb the normal oral microbiome, encouraging the growth of pathogenic bacteria. Flavoured and sweetened vapours further increase the risk of oral disease. This study aimed to compare and evaluate the harmful effects of electronic nicotine delivery systems and conventional cigarettes in adolescents in the Delhi NCR region.

Methods: A total of 84 samples were divided into three groups: Group 1, Group 2 and Group 3. Harmful effects on oral health were determined by examining the DMFT index, plaque index, gingival index, gingival bleeding index, calculus index and level of biomarker IL-1beta in the saliva of e-cigarette and conventional cigarettes adolescent users.

Results: E-Cigarettes are less harmful than cigarettes.

Conclusion: Both e-cigarette use and conventional cigarette smoking negatively impact periodontal health salivary function, and oral inflammatory status when compared to non-smokers with conventional smoking showing greater harm.

Keywords: Electronic Nicotine Delivery System, Conventional Cigarettes, Biomarker IL 1beta, ELISA, Gingival index, plaque, index, DMFT index, Community periodontal ind

INTRODUCTION

Electronic cigarettes are battery-powered nicotine delivery systems also known as electronic nicotine delivery system (ENDS); electronic cigarettes were introduced as a new version of the nicotine delivery system. A study said that E-cigarettes will be less cytotoxic than conventional cigarettes but there is a presence of menthol in E-cigarettes which causes similar harmful effects on oral health.[1] Worldwide, e- cigarette popularity and use among adolescents and children has increased alarmingly (Indian Council of Medical Research, 2019; World Health Organization, 2020).[2] E-cigarettes contain several harmful substances including carcinogens such as formaldehyde, nitrosamines, and metals (e.g. nickel and chromium) and vaping products may increase the risk of cardiovascular diseases and lung disorders.[3] There will be several well-established detrimental effects of smoking on the oral cavity. These include periodontal diseases, impaired wound healing, dental caries, precancerous lesions, and risk of oral carcinoma.[4] Several proinflammatory molecules are established biomarkers of inflammation and are also associated with cigarette smoking. Studies have shown levels of some inflammatory cytokines and chemokines are elevated in electronic nicotine delivery system (ENDS) users, a type of E-cigarette, making them useful indicators of ENDS usage, and helping to comparisons between the toxicity of e-cigarette vapor and cigarette smoke. (i.e. interleukins; IL-1β).[5] Saliva is the medium of diagnostic tool for assessing various components and has recently been advocated owing to comparatively a noninvasive and safer medium than blood collection. Comparative evaluation of biomarkers of saliva to assess the health status has provided comparable results in mediums. Cigarette smoking and its effect on the inflammatory cytokine levels in the smoker's saliva have been investigated previously.[6]

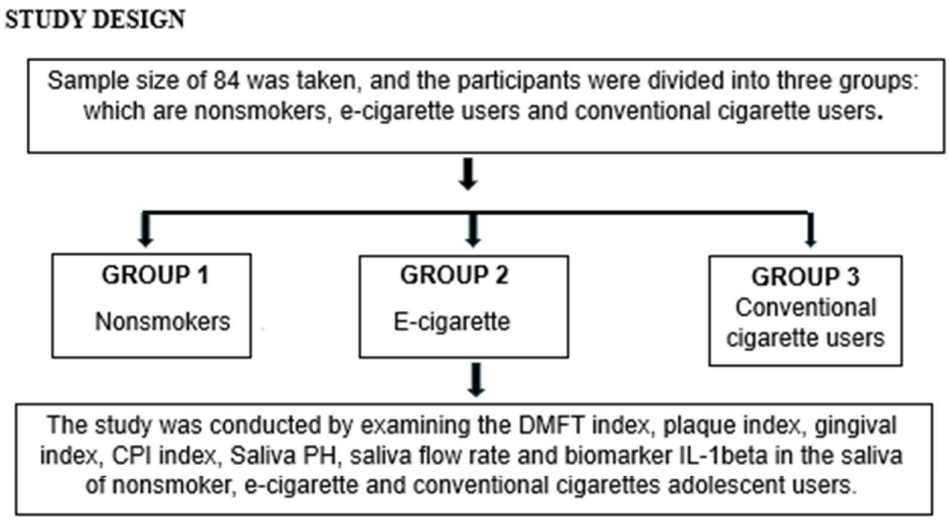


Table 1: study design

AIM AND OBJECTIVES

AIM

The aim of the study was to compare and evaluate the harmful effects of electronic nicotine delivery systems and conventional cigarettes in adolescents in the Delhi NCR region.

OBJECTIVES

- To evaluate the DMFT index, gingival index, plaque index, CPI index, salivary flow rate, salivary pH, and the level of IL-1beta in the saliva of nonsmoker aged 12-15 years.
- To evaluate the DMFT index, gingival index, plaque index, calculus index, CPI index, salivary flow rate, salivary pH, and the level of IL-1beta in the saliva of E-cigarette users aged 12-15 years.
- To evaluate the DMFT index, gingival index, plaque index, calculus index, CPI index, salivary flow rate, salivary pH, the level of IL-1beta in the saliva of conventional cigarette users aged 12-15 years.
- To compare and evaluate the DMFT index, gingival index, plaque index, CPI index, salivary flow rate, salivary pH and the level of IL- 1beta in the saliva of nonsmoker, e-cigarette users and conventional cigarette users aged 12-15 years.

MATERIALS AND METHODS

SAMPLE SELECTION:

The present study included 84 subjects who were selected from different school.

INCLUSION CRITERIA FOR STUDY

- 12- 15 years of age children.
- Index teeth should be present.
- Participants willing to participate in the study

EXCLUSION CRITERIA FOR STUDY

- Participants who do not consent to participate in the study.

- Participants with a systemic condition

STUDY METHOD/TOOLS:

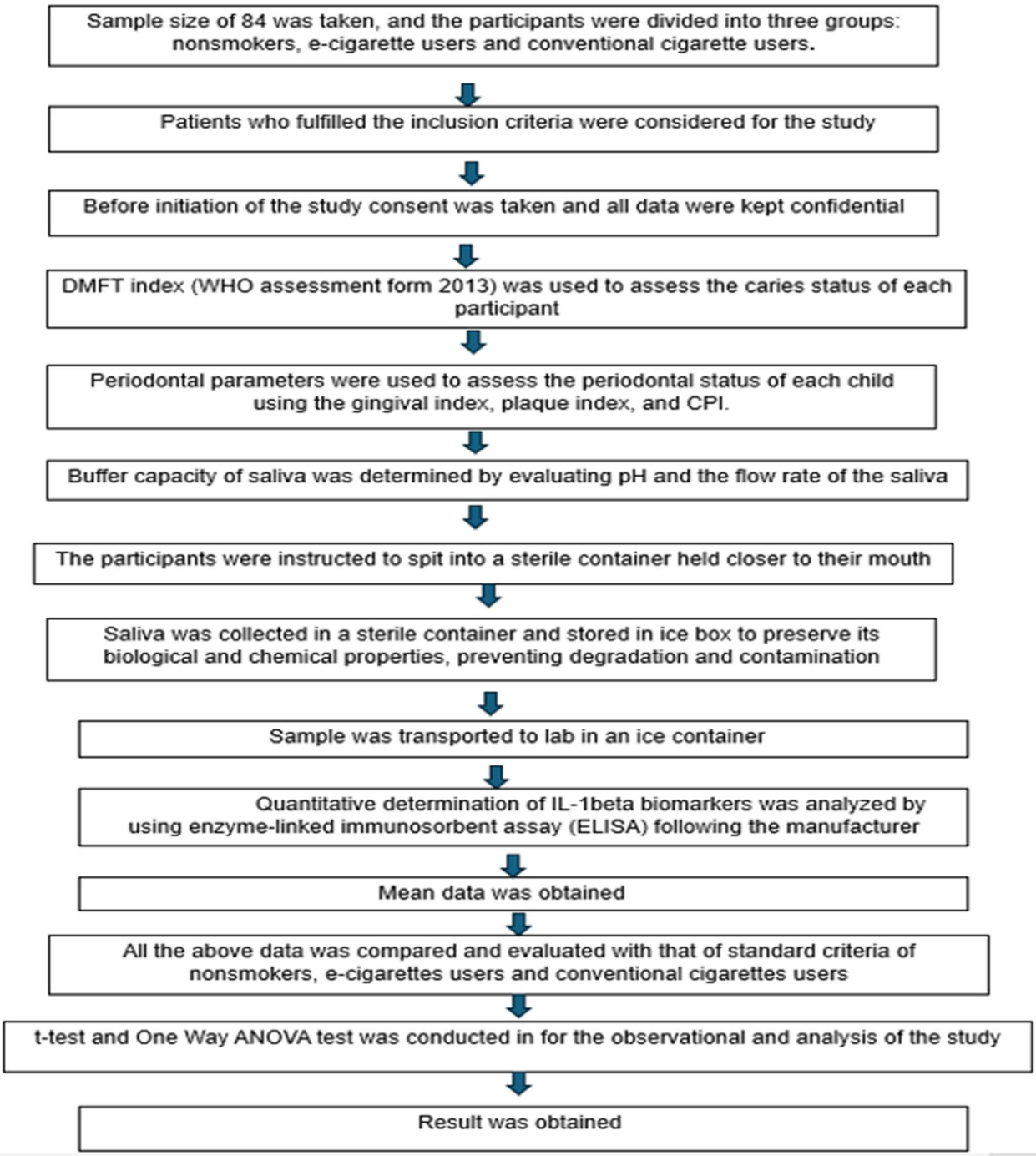
This clinical trial involved 84 subjects. The aim of the study is to compare and evaluate the harmful effects of electronic nicotine delivery systems and conventional cigarettes in adolescents in the Delhi NCR region.

Material used for this study:

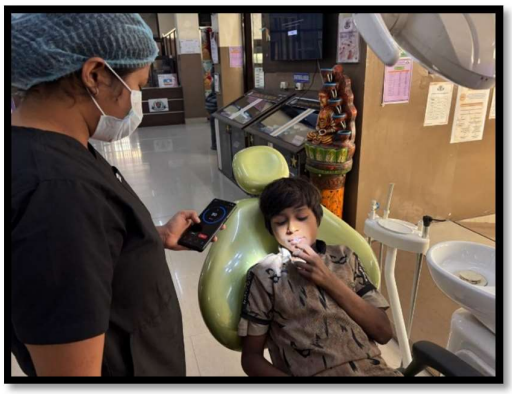
1. Mouth mirrors
2. Periodontal probes
3. Kidney trays
4. Cotton and cotton holder
5. Headcaps
6. Gloves
7. Masks
8. Drapes
9. pH strips
10. Saliva collecting tubes
11. Test tube stand
12. Insulated ice box
13. ELISA unit
14. IL-1beta

DATA COLLECTION PROCEDURE:

The study was conducted by examining the DMFT index, plaque index, gingival index, CPI index, Saliva PH, saliva flow rate and biomarker IL-1beta in the saliva of nonsmoker, e-cigarette and conventional cigarettes adolescent users.


Sample size of 84 was taken, and the participants were divided into three groups: nonsmokers, e-cigarette users and conventional cigarette users.
Patients who fulfilled the inclusion criteria were considered for the study
Before initiation of the study consent was taken and all data were kept confidential
DMFT index (WHO assessment form 2013) was used to assess the caries status of each participant
Periodontal parameters were used to assess the periodontal status of each child using the gingival index, plaque index, and CPI.
Buffer capacity of saliva was determined by evaluating pH and the flow rate of the saliva
The participants were instructed to spit into a sterile container held closer to their mouth
Saliva was collected in a sterile container and stored in ice box to preserve its biological and chemical properties, preventing degradation and contamination
Sample was transported to lab in an ice container
Quantitative determination of IL-1beta biomarkers was analyzed by using enzyme-linked immunosorbent assay (ELISA) following the manufacturer
Mean data was obtained
All the above data was compared and evaluated with that of standard criteria of nonsmokers, e-cigarettes users and conventional cigarettes users
t-test and One Way ANOVA test was conducted in for the observational and analysis of the study
Result was obtained

CLINICAL PROCEDURE:

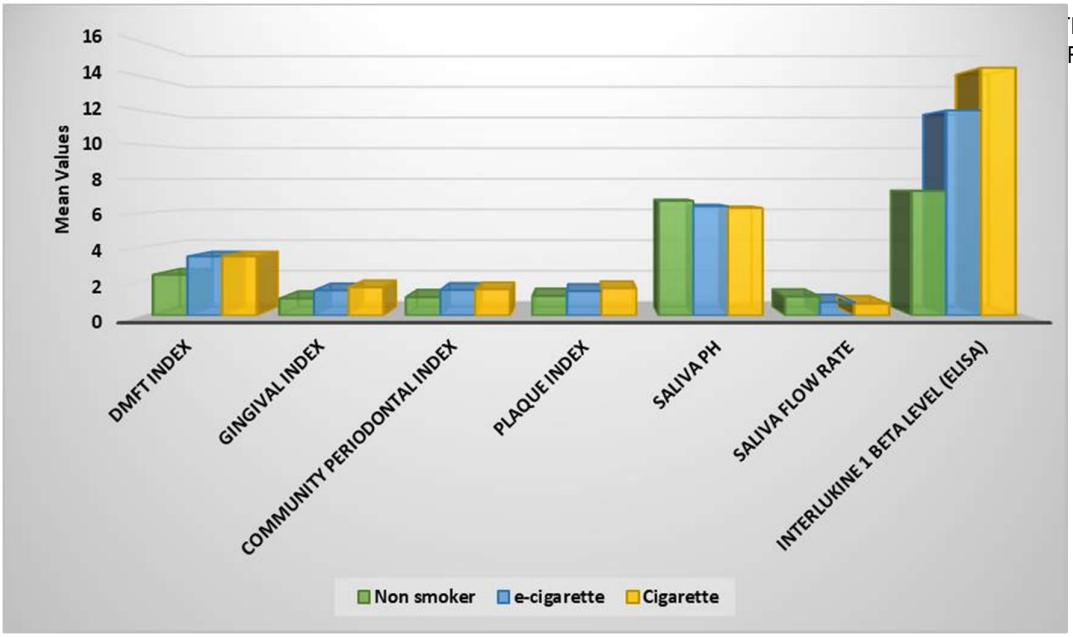


RESULT

Table 1: Evaluation and comparison of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among non-smokers, e-cigarette users and cigarette users.

Indices	Groups	Mean	Std. Deviation	F-value	p-value,S/NS
DMFT index	Non smoker	2.39	2.166	2.887	0.061, NS
	e-cigarette	3.46	2.045		
	Cigarette	3.46	1.503		
Gingival Index	Non smoker	0.99	0.786	5.129	**0.008, S**
	e-cigarette	1.47	0.796		
	Cigarette	1.66	0.821		
Community Periodontal Index	Non smoker	1.07	0.766	3.304	**0.042, S**
	e-cigarette	1.50	0.694		
	Cigarette	1.54	0.793		
Plaque Index	Non smoker	1.15	0.748	2.140	0.124, NS
	e-cigarette	1.43	0.916		
	Cigarette	1.60	0.803		
Saliva pH	Non smoker	6.71	0.460	6.231	**0.003, S**
	e-cigarette	6.39	0.497		
	Cigarette	6.29	0.460		
Saliva Flow Rate	Non smoker	1.11	0.596	3.721	**0.028, S**
	e-cigarette	0.77	0.616		
	Cigarette	0.69	0.612		
Interlukine 1 beta level (ELISA)	Non smoker	7.28	4.876	7.549	**0.001, S**
	e-cigarette	12.0	7.732		
	Cigarette	14.5	8.159		

$p \leq 0.05$ – Significant, CI = 95 %



Graph 1: Evaluation and comparison of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among non-smokers, e-cigarette users and cigarette users.

Table 1 and graph 1: Compares oral-health indices among non-smokers, e-cigarette users, and cigarette smokers. DMFT scores were higher in both smoking groups but not statistically significant (p = 0.061). Gingival Index and CPI showed significant differences (p = 0.008 and p = 0.042), with cigarette smokers exhibiting the poorest gingival and periodontal health. Plaque Index increased across groups but remained non-significant (p = 0.124). Saliva pH was significantly lower in e-cigarette and cigarette users (p = 0.003), while saliva flow rate was also significantly reduced among smokers (p = 0.028). Interleukin-1β levels were markedly higher in both smoking groups (p = 0.001), indicating enhanced inflammatory activity associated with tobacco use.

Table 2: Intergroup comparison of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among non-smokers, e-cigarette users and cigarette users.

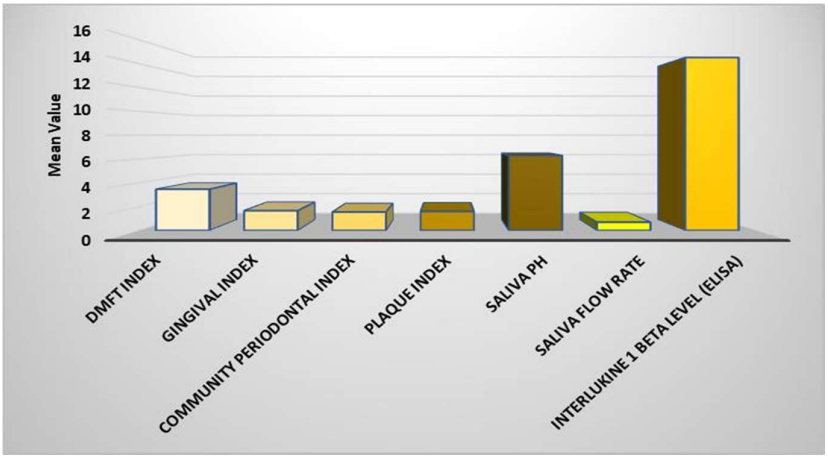
Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Sig.
DMFT index	Non smoker	e-cigarette	-1.071	0.100,NS
		Cigarette	-1.071	0.100,NS
	e-cigarette	Cigarette	0.000	1.000,NS
Gingival Index	Non smoker	e-cigarette	-0.473	0.076,NS
		Cigarette	-0.667*	**0.007, S**
	e-cigarette	Cigarette	-0.193	0.639,NS
Community Periodontal Index	Non smoker	e-cigarette	-0.429	0.090,NS
		Cigarette	-0.464	0.060,NS
	e-cigarette	Cigarette	-0.036	0.983,NS
Plaque Index	Non smoker	e-cigarette	-0.280	0.415,NS
		Cigarette	-0.452	0.107,NS
	e-cigarette	Cigarette	-0.171	0.718,NS
Saliva pH	Non smoker	e-cigarette	0.321*	**0.034, S**
		Cigarette	0.429*	**0.003, S**

	e-cigarette	Cigarette	0.107	0.674,NS
Saliva Flow Rate	Non smoker	e-cigarette	0.337	0.101,NS
		Cigarette	0.417*	**0.032,S**
	e-cigarette	Cigarette	0.080	0.875,NS
Interlukine 1 beta level (ELISA)	Non smoker	e-cigarette	-4.718*	**0.038,S**
		Cigarette	-7.236*	**0.001,S**
	e-cigarette	Cigarette	-2.517	0.382,NS

p ≤ 0.05 – Significant, CI = 95 %

Table No: 2 presents the intergroup comparison of oral-health indices among non-smokers, e- cigarette users, and cigarette smokers. DMFT, CPI, and Plaque Index differences were non- significant across all groups. Gingival Index was significantly lower in non-smokers compared to cigarette smokers (p = 0.007). Saliva pH was significantly higher in non- smokers than in e-cigarette (p = 0.034) and cigarette users (p = 0.003), indicating greater acidity in smokers. Saliva flow rate was significantly higher in non-smokers than cigarette smokers (p = 0.032). Interleukin-1β levels were significantly elevated in both e-cigarette (p = 0.038) and cigarette users (p = 0.001), reflecting increased inflammation among tobacco users.**Table 3:** Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among cigarette users.

Indices	Cigarette	
	Mean	Std. Deviation
DMFT index	3.46	1.503
Gingival Index	1.66	0.821
Community Periodontal Index	1.54	0.793
Plaque Index	1.60	0.803
Saliva pH	6.29	0.460
Saliva Flow Rate	0.69	0.612
Interlukine 1 beta level (ELISA)	14.5	8.159

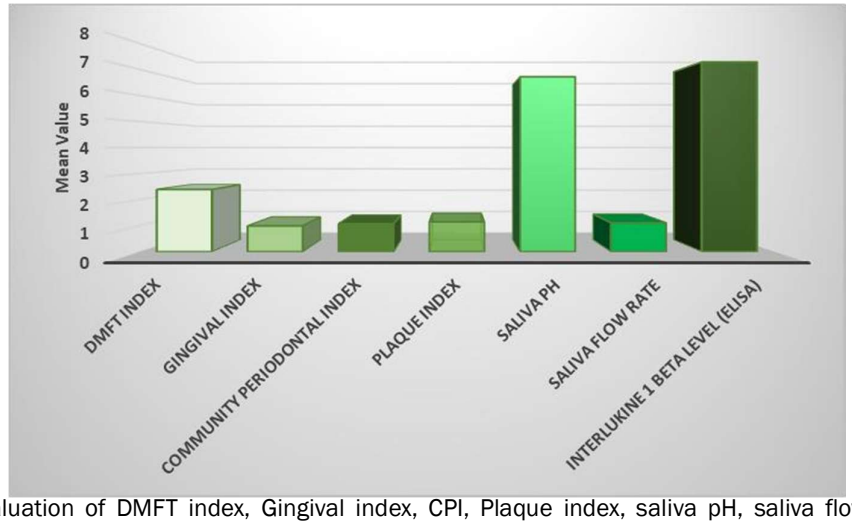


Graph 3: Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among cigarette users.

Table 3 and Graph 3: summarizes the oral-health status of cigarette users. These participants exhibited high mean scores for DMFT index (3.46), Gingival Index (1.66), and Community Periodontal Index (1.54), indicating increased caries experience, gingival inflammation, and periodontal disease compared to other groups. The Plaque Index was also elevated (1.60), reflecting greater plaque accumulation. Salivary parameters showed compromised oral conditions, with a lower saliva pH (6.29), demonstrating increased acidity, and a reduced saliva flow rate (0.69), indicating impaired salivary gland function. Interleukin-1β level was highest in this group (14.5 pg/mL), suggesting a strong inflammatory response associated with cigarette use

Table 4: Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among non-smokers.

Indices	Non smoker	
	Mean	Std. Deviation
DMFT index	2.39	2.166
Gingival Index	0.99	0.786
Community Periodontal Index	1.07	0.766
Plaque Index	1.15	0.748
Saliva pH	6.71	0.460
Saliva Flow Rate	1.11	0.596
Interlukine 1 beta level (ELISA)	7.28	4.876

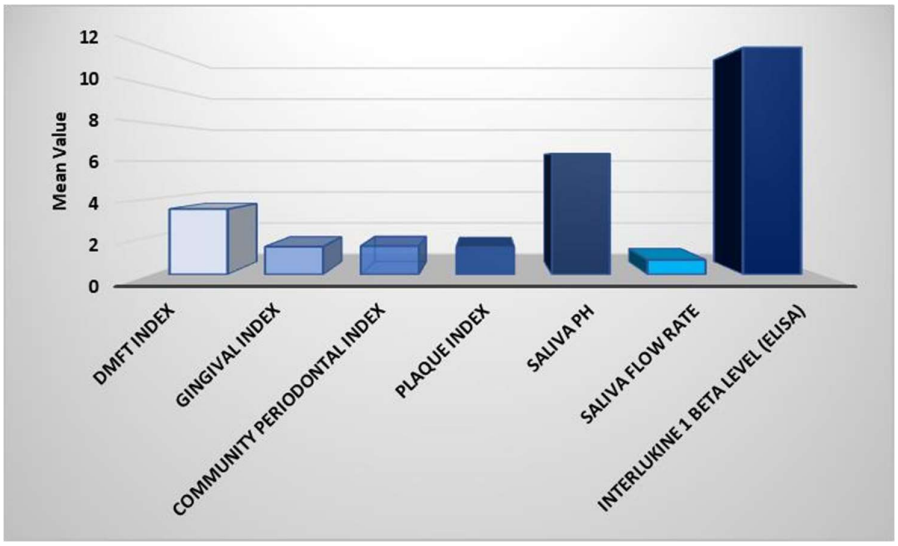


Graph 4: Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among non-smokers.

Table 4 and Graph 4: presents the oral-health parameters of non-smokers, who consistently demonstrated the most favorable values across all indices. The DMFT index (2.39) and Gingival Index (0.99) were lowest in this group, indicating better dental and gingival health. The Community Periodontal Index value (1.07) and Plaque Index (1.15) were also comparatively low, reflecting minimal periodontal involvement and plaque accumulation. Saliva pH was highest among non-smokers (6.71), representing a healthier, less acidic oral environment. They also demonstrated the highest saliva flow rate (1.11), indicating better salivary gland function. Interleukin-1β levels were lowest (7.28 pg/mL), indicating minimal inflammatory activity in the oral cavity.

Table 5: Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among e-cigarette users.

Indices	e-cigarette	
	Mean	Std. Deviation
DMFT index	3.46	2.045
Gingival Index	1.47	0.796
Community Periodontal Index	1.50	0.694
Plaque Index	1.43	0.916
Saliva pH	6.39	0.497
Saliva Flow Rate	0.77	0.616
Interlukine 1 beta level (ELISA)	12.0	7.732



Graph 5: Evaluation of DMFT index, Gingival index, CPI, Plaque index, saliva pH, saliva flow rate, Interleukin beta level among e-cigarette users.

Table 5 and Graph 5**:** outlines the oral-health indices of e-cigarette users, who demonstrated intermediate oral-health status between non-smokers and cigarette users. The DMFT index (3.46) was elevated and like cigarette users, reflecting increased caries experience. Gingival Index (1.47) and Community Periodontal Index (1.50) values indicate notable gingival inflammation and periodontal changes. The Plaque Index (1.43) was higher than non-smokers, suggesting increased plaque accumulation. Saliva pH (6.39) was lower than non-smokers, showing a shift toward acidity, and saliva flow rate (0.77) was reduced, indicating compromised salivary function. Interleukin-1β levels (12.0 pg/mL) were significantly higher than non-smokers, signifying increased inflammatory response associated with e-cigarette use.

Discussion

Tobacco is derived from the leaves of the genus Nicotiana, a plant from the nightshade family, indigenous to North and South America. Archaeological evidence indicates that tobacco was used as early as the first century BC. The Maya people of Central America smoked tobacco leaves during sacred and religious ceremonies. Between 470 and 630 AD, tobacco use spread from the Mississippi Valley as the Maya migrated from southern regions of America, and it was gradually adopted by neighboring and other Native American tribes. Native American shamans used tobacco in religious rituals, while people practicing traditional medicine began using it in various forms to treat conditions such as asthma, earaches, etc. 1 Electronic nicotine delivery systems (ENDS) are widely used, particularly among people who have quit or are attempting to quit traditional combustible cigarette smoking. Many individuals turn to ENDS as an alternative source of nicotine that avoids tobacco combustion, often perceiving them as a less harmful option. As a result, ENDS have become increasingly common in smoking-cessation efforts and among former smokers seeking to maintain abstinence from conventional cigarettes.22

E-cigarette aerosols can activate pattern-recognition receptors like TLRs and stimulate the release of pro-inflammatory cytokines, including IL-1β and TNF-α, especially when menthol-flavored vapours are used.18 e-cigarettes are less harmful than traditional tobacco products, their effects on oral health remain unexplored. Previous research has connected e-cigarette usage to oral health problems, including periodontal disease, dental caries, microbiome disruption, and mucosal ulcers. Long-term exposure to nicotine can harm salivary gland tissue, leading to decreased SFR and xerostomia, even though it may initially boost SFR.26 Among high school students in the United States, e-cigarette use in the past 30 days grew dramatically, rising from 1.5% in 2011 to 16% in 2015—a tenfold increase—surpassing the rate of traditional cigarette smoking, which was 9.3%.27

In present study, it was observed that several oral health measures vary between non-smokers, e-cigarette users and conventional cigarette smokers. While the DMFT index (decayed, missing, filled teeth) was higher in group 2 and group 3 (mean 3.46) than in non-smokers (2.39), the difference did not reach statistical significance ($p = 0.100$).

These results are consistent with earlier studies. Ghazali AF et al. (2018) found that oral health of CS, ES and non-smokers. Smoking had no significant effect ($p= 0.955$ and 0.702). Khattak O, et al. (2024) observed that the oral health of e cigarettes .1

However, some studies present contrasting perspective regarding the extent of DMFT index. Ghazali AF et al. (2019) observed that DMFT index shown higher rate among cigarette smokers, e-cigarette smokers, and non-smokers. The result was significant within the group; cigarette users ($p = 0.005$), e-cigarette users ($p = 0.000$), and control group ($p = 0.025$).2 Ismail A et al. (2019) found that the results were compared by using Paired t-test, the outcomes of which were significant for DMFT Index ($p=0.002$).3

Our results showing significantly elevated GI and CPI among e-cigarette and cigarette users align with recent studies indicating worse periodontal parameters in smokers than non-smokers ($p = 0.008$ and $p = 0.042$ respectively).

The statistically significant higher Gingival Index and Community Periodontal Index scores observed among e cigarette users and cigarette smokers. This finding supports by the Abdul-Jabbar ZM, et al. (2025) who observed that the mean value of GI was significantly higher amongst EC smokers than amongst non-smokers ($p>0.05$).4 Ghazali AF et al. (2018) found that oral health of cigarette smokers, e cigarette smokers, and non-smokers. Smoking was significant for the Gingival Index ($p = 0.000$).6 Ghazali AF, et al. 2019 they found that there were significant findings only for Gingival Index ($p = 0.000$). Similarly, Hasan NW, et al. 2024 observed that GI ($p < 0.05$) were significantly higher among e-cigarette smokers.

In the present study, plaque index scores were higher among E-cigarette and cigarette users but did not reach statistical significance. Similar study observations were found by Javed et al. (2014), who suggested that smoking primarily influences host inflammatory response rather than plaque accumulation itself. Variability in individual oral hygiene practices may explain the non-significant intergroup differences. 5 Similarly These results align with the findings of ALHarthi SS, et al. (2019) they observed that their impact of cigarette

smoking and vaping on periodontal tissues following FMUS was no statistically significant difference in mean PI (P□>□0.05).6

However, some studies present contrasting perspectives regarding the extent of the plaque index. AlQahtani MA, et al. (2018) observed that PI (P < .05), PD ≥ 4 mm (P < .05), and total RBL (P < .01) was significantly higher among CS, WS, and VS compared with NS.7 Alkattan R, et al.(2025) was observed that the plaque index was Compared to e-smoking, nonsmokers had lower PI p-value < .001) while cigarette smokers had higher PI p-value = .135). 8

This present study results showing significantly elevated CPI among e-cigarette and cigarette users align with recent studies indicating worse periodontal parameters in smokers than non-smokers (p = 0.008 and p = 0.042 respectively).

These results are consistent with earlier studies. **Hasan NW, et al. (2024)** observed that the Mean scores of PPD, percentage of pocket depth□≥□4 mm, and CAL (*p*□<□0.05) were significantly higher among cigarette smokers than those in e-cigarette and never-smokers.[9] similarly **Pesce P, et al.(2022)** observed the analysis of BOP values shows a significant difference in the comparison among ES and NS [14] **Alkhalifah AB, et al. 2024** found that ENDS users, BOP was significantly lower at T1 than at baseline. For NS, the BOP at T1 and T2 and the PI at T1 were significantly lower than at baseline.

This study found that e-cigarette and cigarette users had lower salivary pH and reduced saliva flow rate.

Similar observations were reported by **Amirisetty R, et al. (2016)** observed that the Salivary pH, salivary flow rate were decreased in smokers as compared to nonsmokers, which can be used as a diagnostic tool. The overall salivary pH was 5.52±0.51 in nonsmokers and 4.88±0.60 in smokers and salivary flow rate was 0.04±0.08 in nonsmokers and 0.26±0.05 in smokers.[10] **Similarly Singh M, et al. (2015)** observed that the mean (±standard deviation) SFR and pH were 0.20 (±0.05) ml/min and 6.30 (±0.36) respectively in smokers while the mean SFR and pH were 0.36 (±0.06) ml/min and 7.10 (±0.24) in nonsmokers. The difference was statistically significant (*P* = 0.00).[11] **Hasan NW, et al. (2024)** found that the mean unstimulated salivary pH levels were significantly more acidic among cigarette smokers [9] **A'yun Q. et al. (2021)** they revealed that the difference of pH saliva of electric smokers and non-electric smokers got significance value 0.000 (p<0.05). [12]

However, some studies present contrasting perspectives regarding the extent of the flow of saliva and saliva ph. **Fenoll-Palomares C, et al.(2004)** found that Between men and women no differences were found in salivary Ph. [13] **Tashkandi M, et al. (2025)** observed regarding pH, a higher percentage of alkaline pH was observed in non-smokers compared with smokers, and this difference was not statistically significant (p = 0.08). [15]

This study found that e-cigarette and cigarette users had elevated salivary Interleukin-1 beta (IL-1β) compared with non-smokers (p-values 0.003, 0.028, 0.001 respectively).

Similar observations were reported by there was a significant elevation seen in interleukin 1 beta level in saliva of e cigarettes users and conventional cigarettes users **Alhumaidan AA, et al. (2022) f**ound that the IL-1β (p < 0.01) and CL (p < 0.01) In light CS and ENDS users without periodontal disease, clinical periodontal parameters and whole-salivary CL and Il-1β levels remain unchanged after NSPT.[1] similarly **Alnufaiy B, et al.(2025)** found that IL-1B had shown a significant difference between groups in the bivariate analysis (t-test), its association with E-cigs use became non-significant in the multivariate model (OR = 1.01, 95% CI: 1.00–1.02, p = 0.194). [2] **Suzuki N, et al. (2016)**. Observed that the Salivary IL-1β levels were significantly higher in smokers than non-smokers (P = 0.044). [3] **Kamal NM, et al. (2022)** observed that Salivary IL-1β and TGF-β levels were evaluated to assess if the systemic inflammatory response differed between the EC, CS, and NS groups. IL-1β and TGF-β salivary levels were significantly higher in the CS group than in the EC and NS groups (p < 0.05). [4] **Mokeem SA, et al. 2018.** Found that the level of ^{IL}-1β (P□<□0.01) and IL-6 (P□<□0.01) levels were significantly higher among cigarette- and waterpipe-smokers than E-cig users and never-smokers. **Alkhalifah AB, et al. 2024** there was a significant reduction in IL-1β (p<0.05) than at baseline in both groups.

CONCLUSION

The present study compared the effects of e-cigarette use and conventional cigarette smoking on oral health among non-smokers, e-cigarette users, and conventional cigarette smokers. Although DMFT scores were higher among smokers, the difference was not statistically significant. In contrast, periodontal parameters, including the Gingival Index and Community Periodontal Index, were significantly worse in both smoking groups, with conventional cigarette smokers showing the greatest deterioration. Salivary pH and salivary flow rate were significantly reduced among smokers, indicating impaired salivary function and a more acidic oral environment. Salivary IL-1β levels were significantly elevated in both e-cigarette users and conventional cigarette smokers, reflecting increased inflammatory activity, with the highest levels observed in conventional smokers. Overall, non-smokers exhibited the best oral health status, followed by e-cigarette users, while conventional cigarette smokers had the poorest outcomes. The findings indicate that e-cigarettes are not a harmless alternative to conventional cigarettes, as both forms of nicotine use adversely affect periodontal health, salivary function, and inflammatory status. Therefore, dental professionals should consider vaping and smoking as important oral health risk factors and emphasize preventive care, patient education, and early intervention. Further long-term studies are needed to evaluate the cumulative effects of e-cigarette use on oral health.

REFERENCES

1. AlJasser R, Zahid M, AlSarhan M, AlOtaibi D, AlOraini S. The effect of conventional versus electronic cigarette use on treatment outcomes of peri-implant disease. BMC oral health. 2021; 21:1-3.
2. Gupte HA, Chatterjee N, Mandal G, D'Costa M. Adolescents and E-cigarettes in India: A Qualitative Study of Perceptions and Practices. *Asian Pac J Cancer Prev,* 2022 Sep;23(9):2991.
3. Watts C, Egger S, Dessaix A, Brooks A, Jenkinson E, Grogan P, Freeman B. Vaping product access and use among 14–17□year□olds in New South Wales: a cross□sectional study. Aust N Z J Public Health.2022;46(6):814-20.
4. Ghazali AF, Ismail AF, Faisal GG, Halil MH, Daud A. Oral health of smokers and e cigarette users: a case-control study. J. Int. Dent. Med. Res. 2018;11(2):428- 32.
5. McDonough SR, Rahman I, Sundar IK. Recent updates on biomarkers of exposure and systemic toxicity in e-cigarette users and EVALI. Am. J. Physiol. Lung Cell Mol. Physiol. 2021;320(5): L661-79.
6. Verma A, Anand K, Bhargava M, Kolluri A, Kumar M, Palve DH. Comparative evaluation of salivary biomarker levels in e-Cigarette smokers and conventional smokers. J Pharm Bioallied Sci. 2021;13(Suppl 2): S1642
7. Jankowski M, Krzystanek M, Zejda JE, Majek P, et al. E-cigarettes are more addictive than traditional cigarettes among highly educated young adults. Int J Environ Res Public Health. 2019;16(13):2279.
8. Nasser AM, Geng Y, Al-Wesabi SA. Prevalence of cigarette and waterpipe smoking among university students: a systematic review. J Public Health. 2020;28(5):555-567.
9. Gupte HA, Chatterjee N, Mandal G, D'Costa M. Adolescents and e-cigarettes in India: a qualitative study of perceptions and practices.: APJCP. 2022 Sep;23(9):2991.
10. Petrauskiene S, Zemaitienė M, Bendoraitiene EA, et al. Smoking and oral health among Lithuanian adolescents. BMC Oral Health. 2023;23:112.
11. Gunardi I, Amtha R, Hartanto FK, Falatehan N, Heriandi A, Kurniawan AV et al. Perception of Conventional Cigarettes and Vaping among Smokers and Nonsmokers: A Cross-sectional Study. J. Dent. Indones. 2025 Jan 1;32(2):96-103.
12. Ghazali AF, Ismail AF, Faisal GG, Halil MH, Daud A. Comparison of caries experience and periodontal health among cigarette smokers, e-cigarette users and non-smokers. J Int Dent Med Res. 2018;11(3):1043-1049.
13. Moradi G, Bolbanabad AM, Moinafshar A, Adabi H. Oral health status and related factors based on DMFT index in adults. BMC Oral Health. 2019;19:248.
14. Iacob AM, Escobedo Martínez MF, Barbeito Castro E, et al. Oral effects of vaping: mechanisms and clinical implications. Clin Oral Investig. 2024;28(4):2051-2064.
15. Irusa K, White R, Finkelman M. A Comparison of the Caries Risk between Patients Who Use Vapes or E-cigarettes and those Who Use Conventional Cigarettes: A Cross-sectional Study. Dent. Med. Res. 2025 Jan 1;13(1):12-6.
16. Tashkandi M, Nourah D, Alhazmi H, Alsaleh O, Almaghraby M, Alzahrani A, Al-Qurashi A, Saeed A, Alasmari R. Comparative Assessment of Oral Health Findings Among E-Cigarette Users, Conventional Smokers, and Non-Smokers in Makkah City: A Cross-sectional Study. The Open Dentistry J. 2025 Aug 1;19(1).
17. Awartani FA, Al-Jasser NA. The effect of smoking on periodontal health compared with non-smokers in Saudi subjects. Saudi Dent J. 1999;11(3):123-129.

18. Wadia R, Booth V, Yap HF, Moyes DL. A pilot study of the gingival response when smokers switch from smoking to vaping. Br Dent J. 2016;221(11):722-726.
19. Javed F, Abduljabbar T, Vohra F, Malmstrom H, Rahman I. Comparison of periodontal parameters and self-perceived oral symptoms among cigarette smokers, e-cigarette users, and never-smokers. J Periodontol. 2017;88(10):1059-1065.
20. Mokeem SA, Alasqah MN, Michelogiannakis D, Al-Kheraif AA, et al. Clinical, radiographic, and salivary inflammatory markers among cigarette smokers, waterpipe smokers, e-cigarette users, and never-smokers. Clin Oral Investig. 2018;22(9):3207-3217.
21. BinShabaib M, AlHarthi SS, Akram Z, Khan J, et al. Clinical periodontal status and gingival crevicular fluid cytokine profile among cigarette smokers, electronic cigarette users and non-smokers. Int J Environ Res Public Health. 2019;16(23):4583.
22. Alqahtani AS, Alqhtani NR, Gufran K, Alsakr AM, et al. Periodontal treatment needs among conventional and electronic cigarette smokers. J Family Med Prim Care. 2022;11(6):2953-2959.
23. Camoni N, Conti G, Esteves-Oliveira M, Cagetti MG, Campus G. Oral health effects of electronic nicotine delivery systems and heated tobacco products. Int J Environ Res Public Health. 2023;20(5):4018.
24. Thiem DG, Donkiewicz P, Rejaey R, Wiesmann-Imilowski N, et al. Effects of electronic cigarettes on periodontal health: a systematic review and meta-analysis. J Clin Periodontol. 2023;50(8):1002-1015.
25. Almazyad RK, Alazmi SO, Syed NK, et al. Comparative effects of e-cigarette and conventional cigarette smoking on periodontal health. J Periodontol. 2024;95(3):345-353.
26. Alnufaiy B, Alzahrani HG, Lambarte RA, et al. Impact of e-cigarette smoking on periodontal health and inflammatory cytokines. Clin Oral Investig. 2025;29(1):112-120.
27. Saputri D, Nasution AI, Surbakti MR, Gani BA. Correlation between salivary pH and salivary flow rate in smokers with different nicotine levels. Dent J (Maj Ked Gigi). 2017;50(3):147-151.
28. Cichońska D, Kusiak A, Kochańska B, Ochocińska J, Świetlik D. Impact of e-cigarette use on physicochemical properties of saliva. Dent Med Probl. 2019;56(4):403-409.
29. Yohana W, Wihardja R, Adlina I, Rahmaputri A, Farikhah PD. Oral health characteristics of e-cigarette users. J Int Dent Med Res. 2021;14(2):720-726.
30. Hasan NW, Baharin B, Mohd N, Rahman MA, Hassan N. Comparative effects of cigarette and e-cigarette smoking on periodontal and salivary parameters. BMC Oral Health. 2024;24:331.
31. Hassan SS, Askary SH, Bukhari SM, et al. Effect of smoking and smokeless tobacco on salivary flow rate and pH. J Oral Biol Craniofac Res. 2025;15(1):56-62.
32. Kurniawan AV, Amtha R, Gunardi I, Heriandi A, Sari EF. The Impact of Electronic and Conventional Cigarette Use towards Saliva Profile and Oral Microbiota in Adolescents. APJCP. 2025;26(1):309.
33. Suzuki N, Nakanishi K, Yoneda M, Hirofuji T, Hanioka T. Relationship between salivary stress biomarkers, cigarette smoking, and mood states. Environ Health Prev Med. 2016;21(4):243-249.
34. Karaaslan F, Dikilitaş A, Yiğit U. Effects of vaping, smoking and smoking cessation on oxidative stress and inflammatory markers in periodontitis. J Periodontal Res. 2020;55(5):676-684.
35. Javed F, Al-Zawawi AS, Allemailem KS, Almatroudi A, et al. Periodontal conditions and salivary IL-17A and IL-23 levels among marijuana smokers, cigarette smokers, and non-smokers. J Periodontol. 2020;91(8):987-995.
36. McDonough SR, Rahman I, Sundar IK. Recent advances in biomarkers of exposure and toxicity in electronic nicotine delivery systems. BMs. 2021;26(1):1-15.
37. Verma A, Anand K, Bhargava M, Kolluri A, et al. Pro-inflammatory and anti-inflammatory cytokines in saliva of electronic and conventional cigarette smokers. J Oral Biol Craniofac Res. 2021;11(4):487-492.
38. Alhumaidan AA, Al-Aali KA, Vohra F, Javed F, Abduljabbar T. Effect of non-surgical periodontal therapy on salivary cortisol and IL-1β levels in smokers and ENDS users. Clin Oral Investig. 2022;26(9):5749-5757.
39. Kamal NM, Shams NS. Salivary interleukin-1β and transforming growth factor-β in smokers and e-cigarette users. Clin Exp Dent Res. 2022;8(5):1185-1192.
40. Ali D, Kuyunov I, Baskaradoss JK, Mikami T. Periodontal status and salivary IL-15 and IL-18 among cigarette smokers and ENDS users. Clin Oral Investig. 2022;26(5):4039-4048.
41. Al-Mubarak AM, Alqutub MN, Javed F, Vohra F, Abduljabbar T. Salivary cotinine and IL-1β levels in individuals involuntarily exposed to e-cigarette vapor. J Periodontol. 2022;93(7):1008-1015.
42. Alkhalifah AB, Alfuraih NT, Joseph B, Baskaradoss JK. Effect of ultrasonic scaling on GCF IL-1β among ENDS users with gingivitis. Clin Oral Investig. 2024;28(2):741-748.
43. Dolatabadi A, Noori F, Raee A. Effects of conventional and electronic cigarettes on salivary biomarkers: a systematic review. BMC Oral Health. 2024;24:198.

44. Tabnjh AK, Alizadehgharib S, Campus G, Lingström P. The effects of electronic smoking on dental caries and proinflammatory markers: a systematic review and meta-analysis. Front. Oral Health. 2025 Apr 11;6:1569806.
45. Khattak O, Chaudhary FA, Sakoor A, Khattak MU, Ehsan A, Khan FH, Khalid AA, Siddiqui YD, Iqbal A, Issrani R. Oral health status, self-perceptions, and risk awareness among young adult users of electronic cigarettes in Pakistan. Tob. Induc. Dis. 2024 Nov 5;22:10-8332.
46. Ghazali AF, Ismail AF, Daud A. Caries experience among cigarette and e-cigarette users: a 6-month prospective study. J. Pharm. Sci. Res. 2019 Jul 1;11(7):2566-9.
47. Ismail AF, Ghazali AF, Daud A. Effect of Electronic Cigarette Usage on Oral Health: A 6-Month Prospective Study. Indian J. Public Health Res. Dev. 2019 Jun 1;10(6).
48. Abdul-Jabbar ZM, Hoobi NM. Gingival health condition and salivary alkaline phosphatase concentration in relation to electronic cigarette smoking. JBCD. 2025 Mar 15;37(1):14-21
49. Javed T, Younas W, Imran M. Impact of capital structure on firm performance: Evidence from Pakistani firms. International Journal of Int. J. Acad. Res. Econ. Manag. Sci. 2014;3(5).
50. ALHarthi SS, BinShabaib M, Akram Z, Rahman I, Romanos GE, Javed F. Impact of cigarette smoking and vaping on the outcome of full-mouth ultrasonic scaling among patients with gingival inflammation: a prospective study. Clin. Oral Investig. 2019 Jun 1;23(6):2751-8.
51. AlQahtani MA, Alayad AS, Alshihri A, Correa FO, Akram Z. Clinical peri□implant parameters and inflammatory cytokine profile among smokers of cigarette, e□cigarette, and waterpipe. Clin Implant Dent Relat Res. 2018 Dec;20(6):1016-21.
52. Alkattan R, Tashkandi N, Mirdad A, Ali HT, Alshibani N, Allam E. Effects of Electronic Cigarettes on Periodontal Health: A Systematic Review and Meta-Analysis. Int. Dent. J. 2025 Jan 24.
53. Pesce P, Menini M, Ugo G, Bagnasco F, Dioguardi M, Troiano G. Evaluation of periodontal indices among non-smokers, tobacco, and e-cigarette smokers: a systematic review and network meta-analysis. Clin. Oral Investig.,2022 Jul;26(7):4701-14.
54. Amirisetty R, Zade RM, PR R, Patel RP. Salivary Flow Rate and pH Estimation: A Comparative Study Among Smoking and Non-Smoking Subjects with Generalized Chronic Periodontitis. Indian J. Dent. 2016 Jan 1;7(1).
55. Singh M, Ingle NA, Kaur N, Yadav P, Ingle E. Effect of long-term smoking on salivary flow rate and salivary pH. JIAPHD.2015 Jan 1;13(1):11-3.
56. A'yun Q, Hidayati S, Kurniawan F. Comparative status of saliva between electric smokers with non-smokers. Int. res. j. pharm. med. sci. 2021;5(1):4-6.
57. Fenoll-Palomares C, Muñoz-Montagud JV, Sanchiz V, Herreros B, Hernández V, Mínguez M, Benages A. Unstimulated salivary flow rate, pH and buffer capacity of saliva in healthy volunteers. Revista espanola de enfermedades digestivas. 2004 Nov 1;96(11):773-83.