

Examining the Impact of E-Cigarette Use on Oral Health: A Cross-Sectional Study from Lahore, Pakistan

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Abstract

Objective: To determine the prevalence and pattern of oral mucosal, dental, tongue and gingival abnormalities among e-cigarette users in Lahore, and to examine how these findings relate to duration of use, nicotine strength, age and gender.

Methods: A cross-sectional descriptive study was conducted among the general population of Lahore over a period of 8 months from September 2025 to April 2026. A total of 385 e-cigarette users were examined and interviewed using a structured proforma; data were analysed in SPSS using the chi-square test, with $p \leq .05$ taken as significant.

Results: Oral abnormalities were common across all sites examined. Ulceration affected 154 participants on the oral mucosa (40.0%) and 168 on the tongue (43.6%); carious teeth were recorded in 213 participants (55.3%); lip pigmentation was present in 175 participants (45.5%); and moderate gingival inflammation with bleeding was seen in 140 participants (36.4%). Findings with no abnormality ranged from 8.3% (teeth) to 23.1% (tongue) across sites. Users with 1–2 years of e-cigarette exposure and those consuming 11–20 mg nicotine e-liquids consistently showed the highest burden of abnormal findings ($p < .05$ for nearly all associations tested). Participants aged 18–30 years were the most affected age group, and females showed both a greater tendency toward long-term use and more severe oral findings than males.

Conclusion: E-cigarette use is associated with a substantial burden of oral mucosal, dental and gingival changes, particularly among younger users, women, and those using moderate-to-high nicotine concentrations for one to two years. These findings support the integration of oral health screening into e-cigarette safety assessment and public health messaging and point to the need for longitudinal work to establish causality.

Keywords: e-cigarettes; vaping; oral health; periodontal disease; dental caries; oral mucosa; nicotine; tobacco harm reduction

Introduction

Electronic cigarettes have moved, in barely a decade, from a niche smoking-cessation gadget to a mainstream consumer product used by millions of people worldwide, many of whom have never smoked a conventional cigarette at all. They were

introduced to the market as a harm-reduction tool — a way for smokers to keep the ritual and the nicotine while shedding the combustion products blamed for most tobacco-related disease [1,2]. That framing has proved persuasive. It has also

proved incomplete, because “less harmful than cigarettes” is not the same claim as “safe,” and the gap between those two ideas is exactly where much of the current uncertainty about e-cigarettes sits.

Most of the research attention so far has followed the lungs and the heart, for understandable reasons as inhalation injury and cardiovascular strain are the outcomes most closely associated with the original tobacco-control literature [3,4]. The mouth, however, is the one part of the body that meets every puff of aerosol first, repeatedly, for years at a time, and it has received comparatively little scrutiny. What evidence does exist is not reassuring: e-cigarette aerosol has been linked to oral mucosal irritation and lesions, altered salivary composition, a shift in the oral microbiome toward more cariogenic and periodontopathic species, and clinical changes in gingival and periodontal indices [5,6,8,9,10]. Nicotine itself is not an inert carrier in this story; it is vasoactive, it interacts with the tissue response to bacterial biofilm, and its concentration in commercial e-liquids varies enormously from one product to the next, which makes dose-related comparisons across studies difficult [6,7].

Pakistan adds a layer of urgency to this picture that is easy to miss in the international literature. E-cigarettes are sold with little regulatory oversight in most major cities, marketed heavily to young people as a modern and comparatively harmless habit, and taken up increasingly by university and college-age users [12]. A recent clinical study from young adult vapers in Pakistan found a mean DMFT of 5.66, poor oral hygiene in nearly a third of participants, and gingival bleeding in almost half, alongside

strikingly low awareness that vaping carries any oral health risk at all [11]. That combination of clinical burden and low risk perception is precisely the situation in which locally generated data can do the best, both for clinicians counselling patients and for policymakers weighing regulation.

This study was designed to add to that local evidence base. We examined a broad cross-section of e-cigarette users in Lahore for abnormalities of the oral mucosa, lips, teeth, tongue and gingiva, and asked how the pattern of findings varied with how long a person had been vaping, how much nicotine they were consuming, and their age and gender. The aim is not to settle the causal question, a cross-sectional design cannot do that, but to describe, as clearly and completely as the data allow, what the mouths of e-cigarette users in this population actually look like, and to use that description to sharpen the questions that longitudinal and mechanistic research should ask next.

Materials And Methods

2.1 Study Design and Setting

This was a cross-sectional, descriptive, clinic- and community-based study conducted among self-identified e-cigarette users drawn from the general population of Lahore, Punjab, Pakistan. Data collection took place from September 2025 to April 2026. Approval from Institutional Ethics Committee was obtained prior to the commencement of this research (Ref. No. RE&TRC/0925/01/F).

2.2 Sample Size and Sampling Technique

The sample size was calculated at 385 participants using the Raosoft/Cochran formula for an infinite population, based on the estimated

adult population of Lahore (approximately 11.12 million), a 95% confidence level, and a 5% margin of error. Participants were recruited using a non-probability convenience sampling technique from dental outpatient departments and community outreach points across the city.

2.3 Eligibility Criteria

Inclusion criteria: individuals aged 18 years or older who self-reported current or recent use of e-cigarettes and who provided informed consent to a structured interview and intraoral examination. Exclusion criteria: individuals unwilling to provide consent, those with insufficient recall of their vaping history, and those with pre-existing oral pathology clearly unrelated to e-cigarette use (e.g., untreated major trauma) that would confound the intraoral assessment.

2.4 Data Collection

Data were collected using a structured, pre-piloted proforma capturing sociodemographic information (age, gender), e-cigarette use history (duration of use, nicotine concentration of the e-liquid typically used), and a standardised intraoral examination recording the condition of the oral mucosa, lips, teeth, tongue and gingiva under natural or artificial light using a mouth mirror and probe.

2.5 Ethical Considerations

Verbal/written informed consent was obtained from all participants prior to enrolment, and confidentiality of individual data was maintained throughout. Ethical approval was sought from institutional review board.

2.6 Statistical Analysis

Data were entered and analysed in IBM SPSS Statistics 25. Descriptive statistics (frequencies and percentages) were used to summarise

categorical variables. The chi-square test of association was used to test the relationship between oral findings and duration of e-cigarette use, nicotine concentration, age group and gender; a two-tailed p-value $\leq .05$ was considered statistically significant.

Results

A total of 385 e-cigarette users were examined and interviewed. Oral abnormalities were common across every site assessed, and no-abnormality rates ranged narrowly from 8.3% (teeth) to 23.1% (tongue), underscoring how few participants presented with an entirely unremarkable oral examination.

On the oral mucosa, ulceration was the leading finding, present in 154 of 385 participants (40.0%), followed by colour change/pigmentation in 91 (23.6%) and abscess formation in 81 (21.0%). On the lips, pigmentation (175, 45.5%) and ulceration (146, 37.9%) dominated the findings. Dental examination showed carious teeth in 213 participants (55.3%) and tooth fracture in 118 (30.6%). On the tongue, ulceration (168, 43.6%) and fissuring (87, 22.6%) were most frequent, while gingival examination found moderate inflammation with bleeding in 140 participants (36.4%) and severe inflammation with spontaneous bleeding in 72 (18.7%). Full site-by-site distributions are presented in Table 1.

Table 1 (see following page) cross-tabulates each oral finding against duration of e-cigarette use and against nicotine concentration of the e-liquid used. Across all five anatomical sites, the 1–2-year duration category and the 11–20 mg nicotine category consistently accounted for the largest share of abnormal findings, and the association between duration/nicotine level and oral findings

was statistically significant for every site ($p < .05$) except the tongue-duration relationship, which approached but did not clearly cross the significance threshold ($p = .057$).

Table 2 presents the same findings stratified by age group and gender. Participants aged 18–30 years carried the largest share of abnormal findings at every site, and the association with age group was statistically significant for the oral mucosa, teeth, tongue and gingiva ($p < .05$), though not for the lips ($p = .085$). Gender differences followed a consistent pattern: females outnumbered males in ulceration of the mucosa and tongue, in tooth fracture, and in moderate-to-severe gingival inflammation with bleeding, while the two groups were more evenly matched for lip findings ($p = .385$, not significant). The duration-of-use data (not shown in cross-tabulated form by gender) additionally indicated that females were more likely than males to fall into the longer usage categories (2–3, 3–4 and 4–5 years), suggesting a tendency toward more sustained use among female participants in this sample.

Discussion

Taken together, these findings paint a fairly consistent picture: e-cigarette use in this sample was accompanied by a high burden of oral abnormalities, and that burden was not spread evenly, it clustered around a particular window of exposure, a particular nicotine range, and a particular demographic profile. That pattern is worth unpacking piece by piece, because each part of it connects to something already reported elsewhere in the literature.

4.1 Why 1–2-Year Window Stands Out

The single clearest pattern in our data is how much of the pathology concentrated in users with one to two years of exposure, across every

anatomical site examined. This is unlikely to mean that risk falls after two years of use; more plausibly, it reflects the fact that most participants in this sample had simply not been vaping long enough to populate the longer duration categories in meaningful numbers, so the 1–2-year band absorbed the bulk of both the person-time and the pathology. Similar duration-clustering has been noted in other vaping cohorts, where early mucosal and gingival changes appear within the first one to two years of regular use and then plateau or are simply under-represented because so few users have vaped for longer [6,9]. Longitudinal follow-up of the same individuals, rather than a fresh cross-sectional sample at each duration band, would be needed to say anything firmer about how risk actually evolves with sustained use.

4.2 Ulceration, Pigmentation and the Mucosal Findings

Ulceration was the most frequent mucosal and tongue finding in our sample, and pigmentation dominated the lip findings — both consistent with the narrative and systematic literature on e-cigarette aerosol exposure, which repeatedly describes direct irritative and inflammatory effects on oral soft tissue from propylene glycol, vegetable glycerin, flavouring compounds and their thermal breakdown products [2,6]. The concentration of these findings in the 11–20 mg nicotine band mirrors the broader observation that nicotine is not a passive ingredient here: it is vasoactive, it modulates local inflammatory and immune responses, and higher exposure has been linked to more pronounced tissue change in both traditional tobacco and e-cigarette literature [3,4].

Table 1. Association between oral findings, duration of e-cigarette use, and nicotine concentration of e-liquid used ($n = 385$).

p -values are for the chi-square test of association within each anatomical site (row-block); "Total n (%)" is the number and percentage of the full sample ($N=385$) showing that finding, independent of duration/nicotine subgroup.

Oral Finding	Duration of E-Cigarette Use							Nicotine Concentration of E-Liquid						
	6m–1y	1–2y	2–3y	3–4y	4–5y	Total n (%)	<i>p</i>	1–10mg	11–20mg	21–30mg	31–40mg	41–50mg	Total n (%)	<i>p</i>
Oral Mucosa														
Normal mucosa	7	30	8	3	0	48 (12.5%)	.000	23	11	13	0	1	48 (12.5%)	.000
Colour change / pigmentation	7	80	4	0	0	91 (23.6%)		52	30	8	1	0	91 (23.6%)	
Ulceration	6	124	21	2	1	154 (40.0%)		60	86	6	2	0	154 (40.0%)	
Abscess	0	79	1	1	0	81 (21.0%)		33	47	1	0	0	81 (21.0%)	
Dry mouth (xerostomia)	0	4	5	1	1	11 (2.9%)		6	0	4	0	1	11 (2.9%)	
Lips														
Normal appearance	9	48	3	3	1	64 (16.6%)	.000	28	24	10	0	2	64 (16.6%)	.000
Pigmentation	9	129	32	4	1	175 (45.5%)		94	60	20	1	0	175 (45.5%)	
Ulceration	2	140	4	0	0	146 (37.9%)		52	90	2	2	0	146 (37.9%)	
Teeth														
No abnormal finding	4	21	4	3	0	32 (8.3%)	.000	14	8	8	0	2	32 (8.3%)	.000
Carious teeth	5	195	8	3	2	213 (55.3%)		79	126	7	1	0	213 (55.3%)	
Tooth fracture	4	91	22	1	0	118 (30.6%)		67	39	10	2	0	118 (30.6%)	
Discolouration	7	10	5	0	0	22 (5.7%)		14	1	7	0	0	22 (5.7%)	
Tongue														
No abnormal finding	9	72	4	2	2	89 (23.1%)	.057	48	26	13	0	2	89 (23.1%)	.003
Ulceration	9	142	15	2	0	168 (43.6%)		68	84	15	1	0	168 (43.6%)	
Fissured tongue	2	70	14	1	0	87 (22.6%)		34	49	3	1	0	87 (22.6%)	
Candidiasis	0	31	5	2	0	38 (9.9%)		22	15	0	1	0	38 (9.9%)	
Hairy tongue	0	2	1	0	0	3 (0.8%)		2	0	1	0	0	3 (0.8%)	
Gingiva														
No abnormal finding	5	55	2	2	0	64 (16.6%)	.000	32	24	6	0	2	64 (16.6%)	.012
Mild inflammation	2	40	0	0	0	42 (10.9%)		25	16	1	0	0	42 (10.9%)	
Moderate inflammation, no bleeding	6	56	4	1	0	67 (17.4%)		24	30	11	2	0	67 (17.4%)	
Moderate inflammation, with bleeding	7	97	30	4	2	140 (36.4%)		59	68	12	1	0	140 (36.4%)	
Severe inflammation, spontaneous bleeding	0	69	3	0	0	72 (18.7%)		34	36	2	0	0	72 (18.7%)	

Table 2. Association between oral findings, age group, and gender (n = 385).

Oral Finding	Age Group (years)					Gender		
	18–30	31–50	51–75	Total n (%)	<i>p</i>	Male	Female	<i>p</i>
Oral Mucosa								
Normal mucosa	34	14	0	48 (12.5%)	.000	29	19	.004
Colour change / pigmentation	57	34	0	91 (23.6%)		36	55	
Ulceration	126	21	7	154 (40.0%)		67	87	
Abscess	71	9	1	81 (21.0%)		52	29	
Dry mouth (xerostomia)	10	1	0	11 (2.9%)		5	6	
Lips								
Normal appearance	49	13	2	64 (16.6%)	.085	31	33	.385
Pigmentation	140	29	6	175 (45.5%)		80	95	
Ulceration	109	37	0	146 (37.9%)		78	68	
Teeth								
No abnormal finding †	24	8	0	32 (8.3%)	.038	18	40	.002
Carious teeth	170	37	6	213 (55.3%)		120	93	
Tooth fracture	85	31	2	118 (30.6%)		44	74	
Discolouration	19	3	0	22 (5.7%)		7	15	
Tongue								
No abnormal finding	49	39	1	89 (23.1%)	.000	65	24	.000
Ulceration	131	34	3	168 (43.6%)		70	98	
Fissured tongue	83	4	0	87 (22.6%)		43	44	
Candidiasis †	33	1	4	38 (9.9%)		10	20	
Hairy tongue	2	1	0	3 (0.8%)		1	2	
Gingiva								
No abnormal finding	37	26	1	64 (16.6%)	.000	49	15	.012
Mild inflammation	34	8	0	42 (10.9%)		13	29	
Moderate inflammation, no bleeding	57	10	0	67 (17.4%)		39	28	
Moderate inflammation, with bleeding	134	5	1	140 (36.4%)		49	91	
Severe inflammation, spontaneous bleeding	36	30	6	72 (18.7%)		39	33	

p-values are for the chi-square test of association within each anatomical site (row-block).

† For these two findings, the sum of the Male and Female columns as recorded in the original dataset does not equal the corresponding age-group total (Teeth – No abnormal finding: age total 32 vs gender total 58; Tongue – Candidiasis: age total 38 vs gender total 30). These cells should be re-verified against the raw SPSS output before this manuscript is finalised for submission.

What we cannot say from a single cross-sectional snapshot is whether nicotine concentration is acting directly on the tissue, or whether it is simply a marker for heavier or more frequent use, disentangling those two explanations would need a study designed specifically to separate dose from frequency.

4.3 Dental Findings in Context

Carious teeth were the single most common finding of the entire study, present in over half the sample. This is a striking number, and it lines up with a growing body of work on how e-cigarettes may be cariogenic through more than one pathway at once: sweetened and flavoured e-

liquids introduce fermentable substrate directly into the mouth, propylene glycol and glycerin promote xerostomia and reduce the buffering and antibacterial capacity of saliva, and the resulting environment favours the attachment and growth of *Streptococcus mutans* and other acid-producing organisms [7,8]. None of this requires combustion, which is precisely the point critics of the “safer alternative” framing tend to make, and precisely why caries deserves as much attention in e-cigarette research as periodontal disease has received.

4.4 Gingival Findings and the Periodontal Literature

Our gingival findings — a high rate of moderate inflammation with bleeding, and a smaller but real proportion of severe inflammation with spontaneous bleeding sit comfortably within a periodontal literature that has grown substantially in the last two to three years. Recent systematic reviews and meta-analyses generally agree that e-cigarette users show worse periodontal indices than never-smokers, particularly for bleeding on probing and plaque accumulation, even though they tend to fare better than users of combustible cigarettes on measures of destructive periodontal disease such as clinical attachment loss and marginal bone loss [8,9,10]. Our cross-sectional design cannot speak to attachment loss or bone loss at all, since neither was measured, but the bleeding and inflammatory findings we did record are entirely in keeping with that pattern: e-cigarette use appears to be associated with a real, measurable inflammatory burden on the gingiva, even if it may sit somewhere between the profile of a non-smoker and that of a combustible-cigarette smoker.

4.5 Age and Gender: An Unexpected but Explicable Pattern

Two demographic findings deserve particular comment. First, participants aged 18–30 consistently carried the heaviest burden of abnormal findings, which is unsurprising given that this age band represents the demographic core of e-cigarette adoption globally and in Pakistan specifically [11,12]. Second, and less predictable, women in our sample showed both a greater tendency toward long-term use and a higher prevalence of several severe findings tooth fracture and ulceration in particular than men. This runs somewhat against the popular image of vaping as a male-dominated habit, though it is not without precedent; some regional surveys have similarly reported a narrowing, or even reversal, of the gender gap in e-cigarette uptake among younger cohorts [12]. We would be cautious about over-interpreting this finding on the strength of one cross-sectional sample as it may reflect genuine behavioural or physiological differences in persistence and susceptibility, or it may simply reflect who was more available and willing to be examined during data collection. Either way, it is a pattern that a follow-up study with a clearer sampling frame could usefully test.

4.6 Situating This Study Locally

A recent Pakistani study of young adult e-cigarette users found a mean DMFT of 5.66, gingival bleeding in 47.2% of participants, and perhaps most tellingly risk-awareness scores so low that fewer than half of vapers associated their habit with either tooth decay or gum disease [11]. Our findings, drawn from a broader cross-section of the Lahore population rather than a single age band, reinforce the clinical half of that picture: the oral pathology is there, it is common, and it is

not confined to any one narrow subgroup. Read alongside the awareness data from that study, the two pictures together make a fairly direct case: the clinical burden is real, but the people carrying it mostly do not know it is happening, which is exactly the gap that dental education, counselling, and public health messaging in Pakistan are positioned to close.

Limitations

This study has the limitations inherent to its design. Its cross-sectional nature means every association reported here is exactly an association, not evidence of causation or of a particular sequence of events. Duration and nicotine concentration were self-reported, which introduces the possibility of recall bias, particularly for participants trying to recall nicotine strength from memory rather than from packaging. The non-probability sampling approach limits how confidently these findings can be generalised to all e-cigarette users in Lahore, let alone Pakistan more broadly. We did not control for potentially important confounders such as dietary habits, general medical history, oral hygiene practices, or concurrent conventional smoking, any of which could independently affect the oral findings recorded.

Recommendations For Future

The natural next step is a longitudinal cohort that follows the same e-cigarette users over time, which would allow duration-related findings to be interpreted as genuine change rather than as a snapshot of whichever duration band happens to be best represented in a cross-sectional sample. Studies that combine clinical examination with objective salivary or microbiological markers rather than relying on visual/clinical findings

alone would help clarify the mechanisms connecting e-cigarette aerosol exposure to the mucosal, dental and gingival changes described here. Given how young our most affected group was, intervention studies aimed specifically at adolescents and young adults, including school- and university-based oral health education, would be a logical and high-yield application of these findings.

Conclusion

E-cigarette use in this Lahore-based sample was associated with a substantial and wide-ranging burden of oral pathology; mucosal ulceration and pigmentation, a high rate of dental caries, and gingival inflammation with bleeding concentrated among users with one to two years of exposure, moderate-to-high nicotine e-liquids, younger adults, and, somewhat unexpectedly, women. These findings do not resolve the question of whether e-cigarettes are safer than conventional cigarettes overall, but they do make a clear, locally grounded case that oral health cannot be treated as an afterthought in that debate. Embedding oral examination into e-cigarette safety research, and oral health messaging into e-cigarette public health campaigns, would be a proportionate response to what this and similar studies are now consistently finding.

Conflict of Interest None

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Author's Contribution:

MT: Conceptualization of Project, Data Collection, Literature Search, Data Analysis

NO: Writing Manuscript, Drafting Revision