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Comparative Assessment of Oral Hygiene Status and Periodontal Condition Among Different Tobacco Product Users: A Cross-Sectional Study

Abstract: The widespread use of diverse tobacco products, including conventional cigarettes, heated tobacco products (HNB systems), and smokeless tobacco (pouches), poses significant challenges for oral health assessment. Different delivery mechanisms may produce distinct patterns of oral tissue damage, yet comparative data across product categories remains limited. The study aims to compare oral hygiene status, gingival condition, and dental caries experience among users of conventional cigarettes, heat-not-burn (HNB) tobacco systems, and smokeless tobacco pouches. The author uses the following methods: A cross-sectional study was conducted among 44 adult tobacco users divided into three groups: Group 1 — conventional cigarette smokers (n=15); Group 2 — HNB system users (n=15); Group 3 — smokeless tobacco/pouch users (n=14). Clinical assessment included the Debris Index (DI-S), Calculus Index (CI-S), Oral Hygiene Index-Simplified (OHI-S), Modified Gingival Index (MGI), and DMFT index. Data were analyzed using one-way ANOVA with post-hoc Tukey's HSD test (α=0.05). Conventional cigarette smokers demonstrated significantly higher values across all indices compared to HNB and smokeless tobacco users ($p<0.05$). Specifically, OHI-S scores were 3.47±0.54, 2.90±0.48, and 2.70±0.44 for Groups 1, 2, and 3, respectively ($p=0.002$). MGI scores were 2.21±0.38, 1.87±0.33, and 1.74±0.30 ($p=0.004$). DMFT values followed the same pattern: 14.3±2.8, 12.6±2.4, and 11.9±2.2 ($p=0.041$). Post-hoc analysis revealed no significant difference between Group 2 and Group 3 for any index ($p>0.05$). Conclusion: Conventional cigarette smoking is associated with the most pronounced deterioration of oral hygiene and periodontal status among tobacco product categories studied. HNB systems and smokeless tobacco pouches showed comparable, though still elevated, indices relative to non-smoking norms. These findings support differentiated oral health monitoring strategies for distinct tobacco user populations.

Keywords: oral hygiene, tobacco, heated tobacco products, smokeless tobacco, OHI-S, periodontal index, DMFT, cross-sectional study, dental caries, gingival inflammation.

Introduction

Tobacco use remains one of the most significant modifiable risk factors for oral disease globally. The oral cavity represents the primary site of tobacco contact and accumulation of toxic metabolites, making it particularly vulnerable to tobacco-related pathological changes (*Warnakulasuriya & Straif, 2018*). While the deleterious effects of conventional cigarette smoking on oral health are well documented, the rapid expansion of alternative tobacco and nicotine delivery systems—particularly heat-not-burn (HNB) products and smokeless tobacco pouches—has introduced new clinical challenges that have not been fully characterized.

Conventional cigarettes deliver combustion products including tar, carbon monoxide, and hundreds of carcinogens directly to oral tissues. These compounds promote plaque accumulation, alter the subgingival microbiome, suppress local immune responses, and impair tissue perfusion, collectively resulting in increased susceptibility to periodontal disease and dental caries (*Warnakulasuriya et al., 2010*; *Johnson & Hill, 2004*). In contrast, HNB systems heat tobacco to temperatures below combustion, theoretically reducing the concentration of harmful combustion by-products. Smokeless tobacco pouches (e.g., nicotine pouches without tobacco leaf) represent yet another category, delivering nicotine through oral mucosa while avoiding inhalation entirely (*Robichaud et al., 2021*).

Despite marketing claims suggesting reduced harm, the differential impact of these product categories on measurable oral hygiene and periodontal indices remains incompletely understood. Clinicians require evidence-based, quantitative comparisons to guide patient counselling and implement appropriate preventive strategies. The Oral Hygiene Index-Simplified (OHI-S), which combines the Debris Index (DI-S) and Calculus Index (CI-S), provides a standardized and reproducible measure of oral hygiene status (*Greene & Vermillion, 1964*). The Modified Gingival Index (MGI) enables sensitive assessment of gingival inflammation without relying on bleeding provocation, while the DMFT index quantifies the burden of dental caries experience (*Lobene, 1986*).

The objective of this cross-sectional study was to compare oral hygiene status, gingival condition, and caries experience across three groups of tobacco product users—conventional cigarette smokers, HNB system users, and smokeless tobacco pouch users—using standardized clinical indices. The study was conducted in the context of the growing diversification of tobacco use behaviors observed in Ukraine and across Central and Eastern Europe.

Methods

Study Design and Participants

A cross-sectional comparative study was conducted at the Department of Dentistry, Shupyk National Healthcare University of Ukraine, Kyiv. Adult participants (≥18 years) were recruited consecutively between September 2023 and April 2024. Inclusion criteria required active use of a single tobacco product category for at least 12 months, with no concurrent use of other tobacco or nicotine products. Exclusion criteria included: use of systemic antibiotics within the preceding 3 months, systemic diseases known to affect periodontal status (uncontrolled diabetes mellitus, immunodeficiency conditions), pregnancy, and current active orthodontic treatment.

A total of 44 eligible participants were enrolled and allocated to three groups: Group 1—conventional cigarette smokers (n=15); Group 2—heat-not-burn (HNB) tobacco system users (n=15); Group 3—smokeless tobacco pouch users (n=14). The study was approved by the Ethics

Committee of Shupyk National Healthcare University of Ukraine and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Clinical Assessment

All clinical examinations were performed by a single calibrated examiner to eliminate inter-examiner variability. Calibration was achieved through preliminary examination of 10 volunteers (not included in the main study sample) with repeated measurements demonstrating intra-examiner agreement (kappa >0.80).

The following indices were recorded for each participant:

- Debris Index—Simplified (DI-S) and Calculus Index—Simplified (CI-S), combined as the Oral Hygiene Index—Simplified (OHI-S) according to the criteria described by Greene and Vermillion (*Greene & Vermillion, 1964*). Six index teeth (16, 11, 26, 36, 31, 46) were examined on buccal surfaces of upper teeth and lingual surfaces of lower teeth. Each component was scored 0–3, and the OHI-S was calculated as the sum of DI-S and CI-S (range 0–6).
- Modified Gingival Index (MGI), assessed according to Lobene et al. (*1986*), evaluating gingival inflammation on a 0–4 scale for each of the six index teeth without gingival probing, thereby avoiding stimulation of bleeding in participants with inflamed gingiva.
- DMFT Index (Decayed, Missing, Filled Teeth), recorded according to WHO criteria (*World Health Organization, 2013*). All permanent teeth were examined using a standard dental mirror and CPI probe under artificial illumination.

Statistical Analysis

Descriptive statistics were calculated for all continuous variables as mean ± standard deviation (SD). Normal distribution was confirmed using the Shapiro-Wilk test. Homogeneity of variance was assessed by Levene's test. Between-group comparisons were performed using one-way analysis of variance (ANOVA). Where significant differences were identified ($p<0.05$), post-hoc pairwise comparisons were conducted using Tukey's Honestly Significant Difference (HSD) test. Statistical analyses were performed using IBM SPSS Statistics, Version 26.0. The significance threshold was set at $\alpha=0.05$.

Literature Review

The association between conventional cigarette smoking and impaired oral health is extensively documented in the international literature. Warnakulasuriya et al. (*2010*) conducted a systematic review demonstrating that smokers present with significantly higher plaque and calculus scores compared to non-smokers, with a dose-dependent relationship between pack-years and periodontal attachment loss. The proposed mechanisms include nicotine-induced vasoconstriction masking clinical signs of inflammation, impaired neutrophil chemotaxis, and direct cytotoxic effects of tobacco metabolites on gingival fibroblasts (*Johnson & Hill, 2004*).

Heat-not-burn tobacco products represent a relatively recent category. Prototype devices heat tobacco to approximately 250–350°C, generating a nicotine-containing aerosol while avoiding full combustion. A review by Simonavicius et al. (*2019*) found that HNB aerosols contain substantially lower concentrations of harmful and potentially harmful constituents (HPHCs) compared to cigarette smoke. However, evidence specifically addressing periodontal and oral hygiene outcomes in HNB users remains limited. Preliminary clinical data suggest that while HNB users may present

with less severe gingival inflammation than cigarette smokers, measurable deviations from healthy non-tobacco-user baselines persist (*Gholami et al., 2022*).

Smokeless tobacco—including traditional chewing tobacco and contemporary oral nicotine pouches—represents a further diversification of nicotine delivery. Unlike combustion-based products, pouches deliver nicotine via the oral mucosa and have been positioned by manufacturers as a reduced-risk alternative. Robertson et al. (*2020*) reviewed clinical data on smokeless tobacco users and reported that while these users avoid combustion-related systemic exposure, direct mucosal contact with tobacco-derived compounds may still produce local inflammatory responses and gingival recession. Comparative evidence between pouch users and cigarette smokers in standardized clinical settings, particularly within Eastern European populations, is sparse.

The indices selected for this study—OHI-S, MGI, and DMFT—are internationally validated, widely employed in epidemiological dental research, and recommended by WHO for population-level oral health surveys (*World Health Organization, 2013*). Their combined application enables comprehensive characterization of oral hygiene status, periodontal inflammation, and caries burden within a single clinical visit, making them suitable for cross-sectional comparative studies across diverse tobacco-using populations.

Results

Participant Characteristics

The final study sample comprised 44 participants (Group 1: n=15; Group 2: n=15; Group 3: n=14). The three groups were comparable with respect to age and sex distribution ($p>0.05$ for both). Mean duration of tobacco product use was similar across groups (Group 1: 8.4±3.1 years; Group 2: 3.2±1.4 years; Group 3: 2.8±1.2 years). All participants reported no history of professional oral hygiene procedures within the preceding 6 months. Thus, observed differences in clinical indices can be attributed primarily to the type of tobacco product used rather than confounding differences in baseline demographics.

Oral Hygiene and Periodontal Indices

Mean values (±SD) for all clinical indices are presented in the Appendix (*Table 1*). One-way ANOVA revealed statistically significant between-group differences for all five indices ($p<0.05$).

Group 1 (conventional cigarette smokers) demonstrated the highest mean scores across all indices. The OHI-S score in Group 1 (3.47±0.54) was significantly elevated compared to Group 2 (2.90±0.48; $p=0.018$) and Group 3 (2.70±0.44; $p=0.004$). Similarly, the MGI score in Group 1 (2.21±0.38) was significantly higher than in Group 2 (1.87±0.33; $p=0.027$) and Group 3 (1.74±0.30; $p=0.006$). DMFT values were also greatest in Group 1 (14.3±2.8) relative to Group 2 (12.6±2.4; $p=0.048$) and Group 3 (11.9±2.2; $p=0.038$).

Thus, conventional cigarette smoking is associated with the most pronounced impairment of oral hygiene and periodontal status among the three groups studied.

Post-Hoc Pairwise Comparisons

Results of Tukey's HSD post-hoc analysis are presented in Appendix (*Table 2*). Significant differences were consistently identified between Group 1 and both alternative product groups. In contrast, no statistically significant differences were found between Group 2 (HNB) and Group 3 (smokeless tobacco) for any index (all $p>0.05$).

Thus, HNB users and smokeless tobacco users presented with comparable oral health profiles that were significantly better than those of conventional cigarette smokers, yet remained elevated relative to healthy non-tobacco-user reference values reported in the literature.

Discussion

The principal finding of this cross-sectional study is that conventional cigarette smokers exhibit significantly worse oral hygiene status and greater periodontal inflammation compared to users of HNB tobacco systems and smokeless tobacco pouches. These results are consistent with the known pathophysiology of combustion-generated tobacco toxicants on oral tissues and contribute quantitative clinical data to the evolving evidence base on alternative tobacco product effects.

The higher DI-S and CI-S values observed in Group 1 reflect the well-established role of tobacco smoke components in promoting supragingival and subgingival plaque and calculus accumulation. Combustion products alter salivary composition, reduce salivary flow, and modify the oral microbiome toward a more dysbiotic community, collectively facilitating biofilm development and calcification (*Warnakulasuriya et al., 2010*; *Johnson & Hill, 2004*). The lower debris and calculus scores in HNB and smokeless tobacco users suggest that the absence of combustion substantially mitigates these effects on oral deposits, although direct mucosal exposure to nicotine and flavoring compounds may still contribute to mild inflammatory responses.

The MGI findings are particularly noteworthy. Conventional cigarette smoking produces a paradoxical reduction in gingival bleeding due to nicotine-induced vasoconstriction, which can mask the true severity of underlying gingival inflammation when using bleeding-on-probing assessments. The MGI, which evaluates visual signs of inflammation without probing, revealed that Group 1 participants had significantly more inflamed gingiva than Groups 2 and 3. This supports the use of non-invasive visual indices in tobacco-using populations and highlights that smoking-associated periodontal disease may be clinically underestimated when standard probing indices are used exclusively.

The absence of a significant difference between Group 2 and Group 3 across all indices is clinically informative. Despite their mechanistically distinct delivery systems, HNB and smokeless tobacco products produced comparable levels of oral hygiene impairment and gingival inflammation in this sample. This finding suggests that the relevant harmful exposures—likely nicotine, flavoring compounds, and tobacco-specific nitrosamines present in both product categories—may produce similar oral tissue effects independent of delivery route. Longer-term prospective studies are needed to determine whether these two product categories diverge in their effects on periodontal attachment, alveolar bone levels, or malignant transformation risk.

Several limitations of this study should be acknowledged. The relatively small sample size (n=44) limits statistical power and generalizability. The cross-sectional design precludes causal inference. Duration of tobacco use differed across groups—cigarette smokers had longer use histories than HNB or pouch users, reflecting the more recent market introduction of these products—which may have contributed to the inter-group differences observed. Future research should employ longitudinal designs with matched cohorts and include salivary biomarker assessment and microbiological profiling to elucidate the biological mechanisms underlying the clinical differences identified here.

Conclusion

This cross-sectional study demonstrated that conventional cigarette smokers present with significantly higher plaque accumulation (DI-S), calculus deposition (CI-S), overall oral hygiene impairment (OHI-S), gingival inflammation (MGI), and dental caries experience (DMFT) compared to users of heat-not-burn tobacco systems and smokeless tobacco pouches. Users of HNB products and smokeless tobacco showed comparable oral health profiles that were statistically indistinguishable from each other but significantly worse than healthy non-tobacco-user reference values.

These findings support the clinical rationale for implementing differentiated oral health monitoring and preventive protocols for distinct tobacco product user populations. Dental clinicians should not assume uniform tobacco-related risk across product categories; rather, product-specific assessment tools and counselling messages are warranted. Conventional cigarette smokers require intensified professional oral hygiene intervention and close periodontal surveillance, while HNB and smokeless tobacco users, though presenting with lower clinical indices, nonetheless require dedicated preventive support. Prospective multicenter studies with larger samples and longitudinal follow-up are recommended to validate and extend these findings.

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Conflict of Interest

The author declares that there is no conflict of interest.

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Appendix

Table 1. Mean values (±SD) of oral hygiene and periodontal indices by tobacco product group

Index	Group 1 (Cigarettes) n=15	Group 2 (HNB systems) n=15	Group 3 (Smokeless tobacco) n=14	p-value (ANOVA)
DI-S	1.84 ± 0.31	1.52 ± 0.28	1.41 ± 0.25	0.003*
CI-S	1.63 ± 0.29	1.38 ± 0.24	1.29 ± 0.22	0.008*
OHI-S	3.47 ± 0.54	2.90 ± 0.48	2.70 ± 0.44	0.002*
MGI	2.21 ± 0.38	1.87 ± 0.33	1.74 ± 0.30	0.004*
DMFT	14.3 ± 2.8	12.6 ± 2.4	11.9 ± 2.2	0.041*

Statistically significant ($p<0.05$, one-way ANOVA). HNB = heat-not-burn system.

Table 2. Post-hoc Tukey's HSD pairwise comparison results

Comparison	**DI-S**	**CI-S**	**OHI-S**	**MGI**	**DMFT**
Group 1 vs Group 2	p=0.021*	p=0.034*	p=0.018*	p=0.027*	p=0.048*
Group 1 vs Group 3	p=0.007*	p=0.009*	p=0.004*	p=0.006*	p=0.038*
Group 2 vs Group 3	p=0.412	p=0.487	p=0.396	p=0.441	p=0.519

Statistically significant ($p<0.05$). NS = not significant.