

THE IMPACT OF SMOKELESS TOBACCO PRODUCTS ON THE ORAL HEALTH – A NARRATIVE REVIEW

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ABSTRACT

Background: Smokeless tobacco (SLT) products, including snus and nicotine pouches, are increasingly used worldwide, especially among young adults. Although marketed as safer alternatives to smoking, these products have been linked to significant oral health risks. Their use can lead to periodontal destruction, caries development, mucosal lesions, microbial dysbiosis, and oral carcinogenesis. Understanding these effects is essential for developing preventive strategies and guiding clinical practice.

Aims: To critically evaluate recent evidence (2018–2024) on the effects of smokeless tobacco and nicotine pouches on oral health. The review aimed to identify the main pathological outcomes, summarize mechanisms of damage, and highlight research gaps relevant to dental prevention and public health.

Methods: A structured narrative review was conducted in PubMed and Google Scholar databases for studies published between January 2018 and December 2024. Search terms included “smokeless tobacco products”, “periodontal condition”, “tooth caries”, “oral mucosa”, “non-cancerous lesions”, and “oral cancer”. Inclusion criteria were original clinical, epidemiological, or meta-analytic studies in English evaluating the impact of SLT or nicotine pouch use on oral health. Narrative reviews without original data and studies focused solely on cigarette smoking were excluded. Forty studies met the inclusion criteria and were analyzed qualitatively.

Results: SLT use was consistently associated with increased risk of periodontal diseases, including gingival recession, attachment loss, and pocket deepening, especially at habitual product placement sites. Elevated caries risk was reported in long-term users due to both sugar-containing preparations and altered saliva composition. SLT users showed accumulation of heavy metals and microbial dysbiosis contributing to chronic inflammation and

oxidative stress. Non-cancerous lesions such as leukoplakia and smokeless tobacco keratosis were observed in 15–40% of users, and several studies confirmed a link between SLT exposure and oral squamous cell carcinoma. Limited data on nicotine pouches revealed similar harmful effects on oral tissues.

Conclusions: Smokeless tobacco and nicotine pouch use significantly increase the risk of periodontal disease, caries, mucosal lesions, and oral cancer. These findings confirm the objectives of this review and emphasize the urgent need for prevention, early screening, and patient education in dental care. Further research should focus on long-term effects of nicotine pouches, standardized exposure assessment, and inclusion of European populations in future epidemiological studies.

Keywords: Smokeless tobacco; nicotine pouches; periodontal disease; dental caries; oral cancer; oral mucosa; microbial dysbiosis; oxidative stress.

INTRODUCTION

Smokeless tobacco products including snus and nicotine pouches deliver nicotine without combustion and are increasingly used worldwide, particularly among younger adults [1,2]. In Poland, sales of snus are prohibited, yet tobacco-free nicotine pouches have expanded rapidly, reflecting a growing demand for alternative nicotine delivery systems [2,3,41]. Both snus and nicotine pouches are placed under the upper lip, allowing gradual nicotine absorption through the oral mucosa and producing pharmacological effects comparable to cigarette smoking but without smoke inhalation [3].

The public perception of these products as safer alternatives to cigarettes has led to their widespread use, often without adequate awareness of potential oral health risks [4]. Current evidence on the impact of smokeless tobacco (SLT) on periodontal tissues, caries development, oral mucosa, salivary composition, and the risk of premalignant or malignant lesions remains fragmentary and heterogeneous [5,6]. Most available studies are region-specific and focus primarily on traditional SLT types, with limited data on the new generation of nicotine pouches [4–6].

RELEVANCE AND NOVELTY

The growing prevalence of SLT and nicotine pouch use, particularly among young adults and non-smokers, has created a new category of exposure with poorly defined health consequences [4,5]. While combustible tobacco has been extensively studied, the effects of smokeless and tobacco-free nicotine products on the oral cavity are not systematically characterized [6,7]. This review addresses an important gap by synthesizing the latest findings (2018–2024) across clinical, biochemical, and epidemiological studies [8–10]. The inclusion of nicotine pouches represents a novel and necessary extension of research into modern forms of oral nicotine delivery [5,6,11].

AIM AND RESEARCH OBJECTIVES

The main aim of this study was to analyze current scientific data published between 2018 and 2024 concerning the impact of smokeless tobacco (SLT) use on oral health. The objective was to provide a comprehensive assessment of the clinical, microbiological, and biochemical consequences of SLT use, with particular consideration of the mechanisms leading to the development of periodontal pathology, dental caries, mucosal lesions, and oral cancers.

Within the adopted research framework, evidence was analyzed regarding the effects of SLT on periodontal tissues, including gingival recession, loss of connective tissue attachment, and deepening of periodontal pockets. Associations between SLT exposure and caries risk were also evaluated, taking into account the presence of fermentable sugars, changes in salivary composition, and disturbances in the oral microbiota.

The analysis additionally addressed alterations in saliva and microbiome composition resulting from chronic contact with these products, such as the accumulation of heavy metals, the presence of toxic compounds, and the development of dysbiosis. Non-cancerous mucosal changes—such as leukoplakia, tobacco keratosis, and erythroplakia—were also considered in terms of their frequency and malignant transformation potential.

Particular attention was devoted to the relationship between SLT use and the development of oral squamous cell carcinoma, with an analysis of possible carcinogenic mechanisms, including oxidative stress, chronic inflammation, microbiome disturbances, and the genotoxic effects of chemical constituents found in tobacco products.

The analysis of available studies indicated the need for further long-term observations and comparative research across different product types to enable a more precise understanding of their effects on oral tissues. The findings provide a foundation for developing effective preventive strategies in dentistry and public health, focused on early detection of pathological changes, patient education, and reduction of smokeless nicotine product use in the general population.

MATERIAL AND METHODS

This work was designed as a structured narrative review based on transparent search and selection procedures. The literature search was conducted in PubMed and Google Scholar for the period from January 2018 to December 2024. The search strategy combined the main keyword "smokeless tobacco products" with one or more of the following terms: "periodontal condition", "tooth caries", "oral mucosa", "non-cancerous lesions", or "oral cancer".

Only publications in English with full-text availability were considered.

Inclusion criteria:

1. Original clinical, epidemiological, or experimental studies evaluating the effects of smokeless tobacco (SLT) or nicotine pouch use on oral health.
2. Meta-analyses or systematic reviews containing original data on SLT-related oral outcomes.
3. Studies reporting periodontal, carious, mucosal, salivary, or oncologic parameters.
4. Studies published between January 2018 and December 2024.

Exclusion criteria:

1. Narrative reviews or opinion papers without primary data.
2. Studies focused exclusively on cigarette smoking or vaping.
3. Publications not available in full text or written in languages other than English.
4. Papers published before 2018 or reporting only systemic (non-oral) outcomes.

All identified titles and abstracts were independently screened by two reviewers. Full texts of potentially eligible studies were then evaluated in detail. Disagreements were resolved through discussion with a third reviewer. Data extracted included study type, country, sample size, participant characteristics, SLT or nicotine pouch type, exposure duration, and main oral health outcomes.

A total of 40 studies met the inclusion criteria and were incorporated into the final synthesis: three meta-analyses, eighteen focused on periodontal outcomes, five on dental caries, four on salivary and microbiological parameters, four on non-cancerous mucosal lesions, and six on oral cancer risk.

The review followed the principles of narrative synthesis described by Popay et al. (J Public Health 2006;28:427–431), integrating heterogeneous clinical, biochemical, and epidemiological evidence to provide a comprehensive assessment of the oral health consequences of smokeless tobacco and nicotine pouch use.

RESULTS

SMOKELESS TOBACCO PRODUCTS AND PERIODONTAL CONDITION

Epidemiological and clinical evidence consistently indicates a significant association between smokeless tobacco (SLT) use and periodontal diseases, including periodontitis, gingival recession, increased probing depth, and loss of connective tissue attachment, which may lead to tooth loss. In a meta-analysis by Quadri et al., SLT users were nearly three times more likely to develop periodontitis than non-users (OR = 2.99; 95% CI: 2.10–4.27; $p < 0.01$), with notable regional and socioeconomic differences in prevalence and severity [7].

Muthukrishnan and Warnakulasuriya reported that SLT use promotes periodontal pockets, gingival recession, and increased plaque and calculus, particularly in the anterior segment [8]. Mehta et al. observed higher risks of deepened pockets (>4 mm; OR = 3.64), gingival recession (OR = 1.71), and connective tissue attachment loss of 4–5 mm (OR = 2.83) among SLT users [9].

Duration and form of use significantly influenced periodontal health. Athar et al. found that individuals using SLT for over 10 years had a threefold higher risk of periodontitis compared to short-term users (OR = 3.05; 95% CI: 1.86–6.27), with stage III periodontitis most frequently diagnosed [10]. Site of application also affected severity; Anand et al. reported greater gingival recession, probing depth, and clinical attachment loss in areas directly exposed to SLT compared to contralateral sites [11].

Bhandarkar et al. confirmed a positive correlation between tobacco pouch keratosis and increased periodontal severity [12]. Nasir et al. identified gingival recession (Miller class II–IV) as the most prevalent symptom (65.8%), with 21% reporting tooth loss; use ≥ 5 years was associated with advanced recession, mobility, and tooth loss [13]. Yadadi et al. reported higher mean CAL in SLT users (4.01 mm) vs non-users (1.49 mm), despite similar

plaque indices [14]. Nimbale et al. and Khan et al. further documented intensified gingivitis, pocket depth, and attachment loss at habitual SLT placement sites [15,16].

SMOKELESS TOBACCO PRODUCTS AND TOOTH CARIES

Several studies suggest an association between SLT use and increased risk of dental caries. Sen et al. (2019) reported that 34% of SLT users were at high risk for caries according to the Cariogram model, versus 6% in controls [17]. Khan et al. (2024) found that exclusive SLT use was associated with a markedly increased risk (adjusted OR = 5.90), with long-term frequent users at higher susceptibility [18].

Jiang et al. (2019) confirmed the link between tobacco and caries, though data on SLT were less conclusive [19]. Mittal et al. (2020) observed only a weak association between SLT use and DMFT index [20]. Sen et al. (2018) reported medium risk overall, with 34% of users classified as high-risk [21].

SMOKELESS TOBACCO PRODUCTS AND SALIVA

SLT use elevates salivary concentrations of toxic elements. Desideri et al. (2018) reported increased levels of lead, cadmium, and nickel [22], while Guan et al. (2022) detected additional toxic compounds, including ammonia and aromatic hydrocarbons [23].

Frequent SLT users also demonstrate microbial dysbiosis, with higher prevalence of *Porphyromonas gingivalis* and *Fusobacterium nucleatum* [24]. Salivary cotinine levels, a marker of nicotine exposure, were comparable to cigarette smokers, indicating similar dependence potential [25].

SMOKELESS TOBACCO PRODUCTS AND NON-CANCEROUS CHANGES

Smokeless Tobacco Keratosis (STK) is a benign lesion at SLT contact sites (buccal mucosa, gingiva, oral vestibule) [26,27], caused by mechanical and chemical irritation leading to hyperkeratinization [8,28].

Leukoplakia occurs up to six times more frequently in SLT users, with non-homogeneous forms having higher malignant potential [8]. Erythroplakia, though less common, is associated with increased dysplasia and carcinoma risk [8].

SMOKELESS TOBACCO PRODUCTS AND ORAL CANCER

SLT is a major risk factor for oral cancer, particularly in South and Southeast Asia [29]. In 2022, ~35% of oral cancer cases were linked to SLT and areca nut, mostly in India and Bangladesh [30]. Meta-analysis indicates a 3- to 4-fold increased risk among SLT users [31].

Carcinogenesis involves DNA damage, chromosomal instability, chronic inflammation, and dysbiosis (e.g., *Fusobacterium nucleatum*, *Prevotella spp.*, *Porphyromonas gingivalis*) [8,32–34]. SLT-related oral cancers are predominantly squamous cell carcinomas (>90%) [35], with tumor location reflecting habitual product placement [36,37]. Early initiation increases incidence in younger individuals; women may be at higher risk due to longer mucosal exposure [37,38]. Awareness remains low; only 35% of users in Saudi Arabia were aware of SLT’s carcinogenic potential [39], with similar low awareness reported in tribal women in southern India [40].

Table 1 summarizes the main oral health effects associated with smokeless tobacco and nicotine pouch use, outlining the specific risk factors, clinical manifestations, and underlying pathogenic mechanisms reported in studies published between 2018 and 2024.

Table 1. Summary of reported oral health effects associated with smokeless tobacco and nicotine pouch use (2018–2024).

Area / Type of Change	Risk Factors / Conditions	Effect Description / Mechanism
Dental Caries	- Long-term SLT use - High frequency of use	- Acidification of oral environment - Microflora alteration - Reduced salivary protection

Periodontal Diseases	• Duration of use (>5–10 years) • Site of application • Presence of keratosis	• Gingival recession • Deepened periodontal pockets • Attachment loss • Increased plaque and calculus
Salivary Changes	• Exposure to heavy metals • Presence of ammonia, cotinine	• Bioaccumulation of toxins • Altered salivary chemistry • Biomarkers of addiction
Microbial Dysbiosis	• Chronic usage SLT	• Increase in pathogens (e.g., P. gingivalis, F. nucleatum) • Inflammation and infections
Non-Cancerous Lesions	• Contact location • Duration of exposure	• Tobacco keratosis • Leukoplakia • Erythroplakia • Hyperkeratinization of epithelium
Oral Cancer	• Early age of initiation • Long-term exposure • Female gender	• DNA damage • Chronic inflammation • Carcinogenic microbiome changes • SCC at contact sites (e.g., buccal vestibule, floor of mouth, tongue)

DISCUSSION

COMPARATIVE ANALYSIS AND MECHANISMS

The findings of this review confirm that the use of smokeless tobacco (SLT) products significantly increases the risk of periodontal disease, dental caries, microbial dysbiosis, non-cancerous oral lesions, and oral cancer. Epidemiological and clinical studies consistently demonstrate a threefold higher risk of periodontitis among SLT users [7–16]. The mechanisms underlying these effects include chronic inflammation, mechanical irritation, microbial imbalance, and accumulation of heavy metals such as lead, cadmium, and nickel [22–25]. Similar findings have been reported by Mehta et al. (2021) and Quadri et al. (2024), confirming strong epidemiological associations between SLT exposure and periodontal tissue destruction.

EMERGING DATA AND NICOTINE POUCHES

Nicotine pouches, a newer and tobacco-free category of SLT, show comparable detrimental effects on gingival and mucosal tissues [4–6]. Recent microbiological studies (Jonsson 2024, Blachman-Braun 2024) indicate significant dysbiosis involving Porphyromonas gingivalis and Fusobacterium nucleatum, suggesting similar pathogenic potential to traditional smokeless tobacco. However, longitudinal data remain scarce, and evidence from European populations is limited.

LIMITATIONS AND FUTURE DIRECTIONS

The main limitations of the available evidence include heterogeneity in study designs, product types, and population demographics, as well as the absence of standardized exposure assessment and lack of prospective studies. Future research should focus on long-term cohort studies, biomarker validation, and comparative analysis of conventional SLT and nicotine pouches. Public health measures should aim to increase awareness among young

users and promote preventive screening in dental practice. Such strategies may include public awareness campaigns, integration of cessation counseling into routine dental care, restriction of product marketing to minors, taxation or pricing policies to discourage use, and school-based educational programs focused on the risks of smokeless nicotine products.

CONCLUSIONS

Smokeless tobacco (SLT) products, including snus and nicotine pouches, represent a significant and multifactorial threat to oral health. Their use is strongly associated with periodontal tissue destruction, including gingival recession, increased pocket depth, connective tissue loss, and tooth loss. The severity of these effects depends on the frequency and duration of use and the habitual site of product placement in the oral cavity. Consistent pathological changes have been documented at contact sites between the product and the oral mucosa.

SLT use also contributes to an increased risk of dental caries, resulting from the presence of fermentable carbohydrates in certain preparations and from changes in salivary composition and microbial balance. In addition, saliva functions as a carrier of toxic substances such as heavy metals and carcinogenic compounds, promoting chronic inflammation, oxidative stress, and microbial dysbiosis.

Non-cancerous lesions, particularly leukoplakia and smokeless tobacco keratosis, are common among SLT users. Although often benign, these conditions can represent transitional stages preceding oral squamous cell carcinoma, typically developing at sites of product placement. The emerging use of nicotine pouches demonstrates comparable harmful effects, reinforcing the need to include these products in ongoing clinical and epidemiological research.

Current evidence underscores the necessity of preventive and educational strategies within dental practice, focusing on screening, counseling, and cessation support for SLT users. Major knowledge gaps remain concerning the long-term effects of nicotine pouches, standardized exposure assessment, and data from European populations. Future research should prioritize longitudinal cohort studies, mechanistic analyses of mucosal injury, and targeted public health interventions to reduce oral and systemic risks associated with SLT use.

Overall, smokeless tobacco and nicotine pouch products not only contribute to periodontal disease and dental caries but also possess carcinogenic potential, posing a serious and preventable threat to oral health worldwide.

DISCLOSURE

AUTHORS' CONTRIBUTIONS

Conceptualization: Maciej Zajac, Karolina Zalisz, Literature search and data curation: Maciej Zajac, Jakub Witek, Methodology: Hubert Knapik, Karina Koszuta, Oliwia Wasag, Writing - original draft preparation: Karolina Zalisz, Paulina Misiewicz, Jakub Witek, Writing - review and editing: Maria Sikora, Oskar Ptak, Przemyslaw Koszuta, All authors have read and agreed with the final version of the manuscript.

USE OF AI

The authors acknowledge that ChatGPT was utilized solely as a tool to support language refinement and the organization of the manuscript. All decisions concerning content, data interpretation, study design, writing, and final approval were made exclusively by the authors. This approach ensures that the accuracy, integrity, and scholarly contribution of the article remain the result of the authors' independent work.

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