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SYSTEMIC HEALTH CONSEQUENCES OF SMOKELESS TOBACCO AND NOVEL ORAL NICOTINE PRODUCTS WITH A PARTICULAR FOCUS ON THE CARDIOVASCULAR SYSTEM: A NARRATIVE REVIEW

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ABSTRACT

Background: Global nicotine consumption is shifting from cigarettes to alternative nicotine delivery systems (ANDS), specifically smokeless tobacco (ST) and oral nicotine pouches (NPs). Often marketed as "tobacco-free" and safer, these products deliver high nicotine doses, including synthetic forms, via the oral mucosa, bypassing traditional regulations and creating new public health challenges.
Aim: To synthesize scientific evidence on the systemic health consequences of ST and NPs, focusing on cardiovascular risks and long-term clinical outcomes.
Material and methods: A systematic search of electronic databases (PubMed, Scopus, Google Scholar) was conducted. Thirty-five peer-reviewed sources—comprising original research, systematic reviews, and longitudinal cohort studies—were analyzed using a qualitative synthesis approach.
Results: Pharmacokinetic data show that modern NPs achieve peak plasma levels and total exposure comparable to or exceeding cigarette smoking. Chronic use is linked to acute hemodynamic stress, increasing heart rate (10–15 bpm) and blood pressure (5–10 mmHg). Epidemiological studies indicate a heightened risk of fatal cardiovascular events, including myocardial infarction and stroke, with relative risks reaching 2.1 in younger cohorts. Furthermore, these products are associated with oral pathologies (recession, leukoplakia), adverse reproductive outcomes (fetal toxicity), and metabolic disorders like type 2 diabetes.
Conclusions: ST and NPs are not cardiovascularly inert; they exert significant sympathomimetic stress and pose substantial systemic risks. Their addictive potential and rising popularity among youth and athletes necessitate urgent regulatory oversight and a clinical focus on total nicotine cessation.

KEYWORDS

Smokeless Tobacco, Nicotine Pouches, Cardiovascular System, Snus, Systemic Health, Public Health

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1. Introduction

The global landscape of nicotine and tobacco consumption is currently undergoing a profound transformation, marked by a decisive shift from traditional combustible cigarettes to a diverse array of alternative nicotine delivery systems (ANDS) (1, 2). While the prevalence of traditional smoking has declined in many high-income countries due to stringent public health policies and increased awareness of its lethal consequences, the tobacco industry has successfully introduced non-combustible alternatives that occupy a growing share of the market (3, 4). Among these, smokeless tobacco (ST) products, such as Swedish-type snus, and the rapidly emerging category of "tobacco-free" oral nicotine pouches (NPs), represent a significant frontier in both consumer preference and public health debate (5, 6).

Nicotine pouches, in particular, have seen an exponential rise in popularity since their introduction to the global market around the turn of the decade (6, 7). Unlike traditional smokeless tobacco, which relies on fermented or pasteurized tobacco leaf, these novel pouches contain nicotine salts—either derived from tobacco or, increasingly, produced through chemical synthesis—combined with plant-based fibers, pH adjusters, and a wide variety of flavoring agents (7, 8, 9). This "tobacco-free" branding is a cornerstone of their marketing, often leading consumers, particularly young adults and adolescents, to perceive them as significantly less harmful than any tobacco-based product (8, 10). Furthermore, the emergence of synthetic nicotine has allowed manufacturers to bypass traditional tobacco regulations in many jurisdictions, creating a "regulatory gray zone" that complicates public health monitoring (2, 9).

The promotion of these products is often framed within the context of "tobacco harm reduction" (THR). Proponents argue that for individuals who are unable or unwilling to quit nicotine entirely, switching to non-

combustible oral products can drastically reduce exposure to the thousands of toxic and carcinogenic combustion byproducts found in cigarette smoke, such as carbon monoxide and polycyclic aromatic hydrocarbons (11, 12, 13). Comparative risk assessments often place smokeless products at a lower point on the "continuum of risk," estimating them to be significantly less hazardous than combustible cigarettes in terms of respiratory disease and lung cancer (11, 12). However, this reduction in certain toxicants does not equate to absolute safety.

The systemic health consequences of sustained, high-dose nicotine exposure through the oral mucosa remain a subject of intense scientific scrutiny. Unlike the transient spikes in nicotine levels associated with smoking, the pharmacokinetics of modern oral pouches—which can contain up to 20 mg of nicotine per serving or more—facilitate a rapid and prolonged systemic uptake (7, 14). Nicotine is a potent sympathomimetic alkaloid that exerts profound effects on the autonomic nervous system. Of particular concern is its impact on the cardiovascular system, where it triggers the release of catecholamines, leading to acute hemodynamic stress, increased myocardial oxygen demand, and potential long-term vascular remodeling (15, 16, 17).

Recent epidemiological data and clinical studies have begun to challenge the narrative of the complete safety of these products. Evidence suggests that long-term use of smokeless tobacco is associated with an increased risk of fatal cardiovascular events, including myocardial infarction and stroke, as well as adverse effects on metabolic health and oral integrity (18, 19, 20, 21). In the athletic community, where products like snus and nicotine pouches are frequently used for their discreet nature and perceived performance-enhancing effects (e.g., increased focus or hunger suppression), the potential for adverse cardiovascular strain is particularly relevant (17).

Given the rapid evolution of the nicotine market and the increasing prevalence of oral nicotine use among non-smokers and youth, a comprehensive re-evaluation of the available evidence is necessary. This narrative review aims to synthesize current research on the systemic health consequences of smokeless tobacco and novel oral nicotine pouches. By analyzing 35 peer-reviewed sources, including large-scale cohort studies and modern toxicological assessments, this paper focuses specifically on the cardiovascular implications of these products, while also addressing their impact on oral health and their role in the modern public health landscape.

2. Research materials and methods

This narrative review was conducted to synthesize and critically evaluate current scientific evidence regarding the systemic health impacts of smokeless tobacco (ST) and novel oral nicotine pouches (NPs), with a particular focus on the cardiovascular system.

2.1. Search strategy

A comprehensive literature search was performed across major electronic databases, including PubMed, Scopus, Embase, Google Scholar, and the Cochrane Library. The search strategy was designed to capture both historical landmark studies on smokeless tobacco and the most recent data on emerging nicotine products. The following keywords and Boolean operators were utilized: ("smokeless tobacco" OR "snus" OR "nicotine pouches" OR "oral nicotine") AND ("cardiovascular system" OR "hemodynamics" OR "heart rate" OR "blood pressure" OR "toxicity" OR "systemic health"). Reference lists of identified reviews and meta-analyses were also manually searched to ensure the inclusion of all relevant primary sources.

2.2. Eligibility criteria

To ensure the scientific rigor of the review, specific inclusion and exclusion criteria were established. Studies were included if they met the following requirements:

1. Original research, systematic reviews, or meta-analyses published in peer-reviewed journals.
2. Research focused on the pharmacokinetic profiles of oral nicotine delivery or the toxicological assessment of product constituents.
3. Epidemiological or clinical studies investigating cardiovascular outcomes, such as heart rate variability, arterial stiffness, myocardial infarction, and stroke.
4. Studies comparing different forms of non-combustible nicotine delivery (e.g., traditional snus vs. "tobacco-free" synthetic pouches).

Exclusion criteria primarily targeted non-peer-reviewed content, articles focusing solely on combustible tobacco without reference to oral alternatives, and studies with significant methodological flaws.

2.3. Data collection and analysis

Data from the selected 35 sources were extracted and categorized based on thematic areas: pharmacokinetics, acute and chronic cardiovascular toxicity, long-term epidemiological mortality data, and localized oral health consequences. A qualitative synthesis approach was employed to analyze the findings across different demographics, including youth and athletes, while accounting for the chemical variations between traditional tobacco-based products and modern synthetic nicotine formulations.

2.3.1. Study selection process

The initial screening involved an assessment of titles and abstracts to remove duplicates and irrelevant entries. Subsequently, the remaining articles underwent a full-text review. The selection process was guided by the need for high-quality evidence, leading to the final inclusion of 35 key sources that provided the most robust data regarding systemic exposure and cardiovascular risk. This final set included authoritative policy statements from organizations such as the American Heart Association and global systematic reviews that utilized the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

3. Research Results

3.1. Classification and chemical composition of oral nicotine products

The landscape of oral nicotine delivery has evolved into two distinct categories: traditional smokeless tobacco (ST) and modern "tobacco-free" oral nicotine pouches (NPs) (2, 3, 4). Traditional ST, which includes products such as Swedish snus, moist snuff, and chewing tobacco, is characterized by the presence of pasteurized or fermented tobacco leaf (5, 22). Chemically, these products are complex matrices containing not only nicotine but also a variety of tobacco-specific nitrosamines (TSNAs), such as N’-nitrosonornicotine (NNN) and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), which are potent carcinogens.

In contrast, novel nicotine pouches represent a significant technological departure. These products typically consist of a porous cellulose pouch filled with nicotine salts, water, plant-based fibers (e.g., microcrystalline cellulose), sweeteners (like xylitol), and pH adjusters (3, 7). A critical development in this category is the use of synthetic nicotine—alkaloid nicotine produced through chemical synthesis rather than extraction from tobacco plants (9). Synthetic nicotine products often bypass traditional regulatory frameworks while providing a high-purity S-nicotine isomer, though some formulations may contain racemic mixtures (R/S-nicotine) whose long-term biological impacts are less understood (2, 9).

Furthermore, the chemical appeal of NPs is enhanced by a vast array of flavorings, including menthol, fruit esters, and cooling agents (6, 8). These additives are not merely for sensory appeal; menthol, for instance, can exert a mild anesthetic effect on the oral mucosa, potentially facilitating the use of higher nicotine concentrations without the expected irritation (8, 17). Toxicological assessments of these flavorings have raised concerns about localized cellular stress and inflammatory responses in human gingival fibroblasts and epithelial cells (7, 20, 23).

3.2. Pharmacokinetics of oral nicotine delivery

The systemic health impact of any nicotine product is primarily dictated by its pharmacokinetic profile—specifically the rate and extent of nicotine absorption into the bloodstream. Oral nicotine products utilize the high vascularity of the buccal mucosa to bypass first-pass hepatic metabolism, allowing for efficient systemic uptake (7, 14).

Comparative pharmacokinetic studies have revealed that while the time to reach maximum plasma concentration (Tmax) is generally longer for oral pouches (typically 30 to 60 minutes) than for combustible cigarettes (approximately 5 to 10 minutes), the peak plasma concentration (Cmax) and the total systemic exposure (Area Under the Curve, AUC) can be significantly higher in NP users (7,14). For instance, an 8 mg nicotine pouch can produce a Cmax that exceeds that of a standard 10-puff cigarette, while modern high-dose pouches (up to 20 mg or higher) deliver massive amounts of nicotine that can lead to rapid dependence (7, 14).

The efficiency of this absorption is highly dependent on the product's pH. Manufacturers utilize pH adjusters (such as sodium carbonate) to maintain an alkaline environment in the mouth, which increases the proportion of "free" or unionized nicotine—the form that most readily penetrates biological membranes (5, 7). This sustained systemic presence of nicotine, often lasting longer than the "spikes" observed in smoking, results in a prolonged state of physiological arousal (15, 16). In frequent users, this can lead to "nicotine stacking," where plasma levels remain elevated throughout the day, exerting continuous pressure on the autonomic nervous system and the cardiovascular apparatus (15, 17).

3.3. Cardiovascular toxicity and clinical outcomes

3.3.1. Sympathomimetic effects and acute hemodynamics

The cardiovascular impact of oral nicotine products is primarily mediated by the potent sympathomimetic properties of nicotine. Upon absorption through the buccal mucosa, nicotine binds to nicotinic acetylcholine receptors (nAChRs) in the autonomic ganglia and the adrenal medulla, triggering a rapid systemic release of catecholamines, specifically epinephrine and norepinephrine (15, 16). This biochemical cascade results in immediate and significant hemodynamic changes. Clinical observations consistently report acute increases in resting heart rate (by 10–15 beats per minute) and a transient elevation of both systolic and diastolic blood pressure (typically by 5–10 mmHg) following the administration of smokeless tobacco or high-dose nicotine pouches (15, 16, 24).

These acute effects increase myocardial oxygen demand while simultaneously inducing peripheral vasoconstriction, which can reduce coronary blood flow (15). In the context of "nicotine stacking"—a phenomenon common among frequent users of nicotine pouches where plasma levels remain consistently high—the heart and vasculature are subjected to prolonged periods of sympathetic overstimulation (7, 14, 17). This sustained stress is particularly concerning for individuals with underlying cardiovascular conditions, as it may lower the threshold for acute cardiac events (16, 21).

3.3.2. Long-term cardiovascular morbidity and mortality

While the absence of combustion products significantly reduces the risk of respiratory diseases, the long-term use of smokeless tobacco (ST) has been definitively linked to increased cardiovascular mortality. Landmark epidemiological studies, including the massive cohort of over 135,000 Swedish construction workers, revealed that exclusive snus users face a significantly higher relative risk (RR 1.4) of cardiovascular death compared to non-tobacco users (19). Notably, this risk was even more pronounced among younger men (aged 35–54), where the relative risk of cardiovascular death reached 2.1 (19).

Global data from the INTERHEART study, which analyzed risk factors for myocardial infarction (MI) across 52 countries, confirmed that ST use is an independent risk factor for non-fatal MI, albeit with lower odds ratios than combustible cigarettes (25). Furthermore, longitudinal analyses have demonstrated that ST users have an increased risk of fatal stroke and sudden cardiac death (18, 21, 26). These outcomes are likely driven by chronic nicotine-induced hypertension and a pro-thrombotic state. In the United States, prospective studies such as the Cancer Prevention Studies (CPS-I and CPS-II) have also reported higher death rates from heart disease and stroke among current users of snuff and chewing tobacco compared to never-users (18).

3.3.3. Vascular integrity and chronic complications

Beyond acute hemodynamic stress, chronic nicotine exposure contributes to accelerated atherogenesis and vascular damage. Nicotine promotes endothelial dysfunction—a critical early step in the development of atherosclerosis—by reducing the bioavailability of nitric oxide and increasing oxidative stress within the vascular wall (15, 17, 20). Studies utilizing pulse wave velocity (PWV) measurements have indicated that chronic ST and electronic nicotine delivery system (ENDS) users exhibit increased arterial stiffness, which is a strong predictor of future adverse cardiovascular outcomes (15, 21).

Recent evidence also suggests a link between smokeless tobacco use and the prevalence of heart failure (27, 28). Data from the Population Assessment of Tobacco and Health (PATH) study indicate that ST users have significantly higher odds of a heart failure diagnosis compared to never-tobacco users, potentially due to chronic pressure overload and myocardial remodeling (27, 28). Furthermore, high-intensity use (exceeding four cans per week) has been associated with metabolic disturbances, including an increased risk of type 2 diabetes and metabolic syndrome, further compounding the overall cardiovascular risk profile (13, 29). The emergence of high-dose nicotine pouches (NPs) raises similar concerns; while they lack tobacco nitrosamines, their capacity to deliver rapid, high-concentration nicotine "hits" may replicate or exceed the vascular strain observed with traditional smokeless products (3, 7).

3.4. Oral health and systemic consequences

3.4.1. Localized impact on the oral mucosa and periodontium

While systemic cardiovascular risks are often prioritized, oral nicotine products exert a direct and significant pathological influence on the tissues of the oral cavity. The habitual placement of smokeless tobacco (ST) or nicotine pouches (NPs) in the buccal or labial vestibule creates a localized environment of chronic chemical and mechanical irritation (20, 23). Clinical examinations of ST users frequently reveal the presence of "snuffer's keratosis" or "tobacco pouch keratosis"—a white, wrinkled mucosal lesion characterized by epithelial hyperplasia and hyperkeratosis at the site of product placement (20, 30). While many of these lesions are reversible upon cessation, chronic exposure to tobacco-specific nitrosamines (TSNAs) in traditional products remains a significant risk factor for the development of oral squamous cell carcinoma (30, 31).

Regarding periodontal health, the use of oral nicotine products is strongly associated with gingival recession and the permanent loss of clinical attachment (20, 32). Nicotine-induced vasoconstriction of the gingival microcirculation can mask the early inflammatory signs of periodontal disease, such as bleeding on probing, potentially leading to delayed diagnosis and accelerated alveolar bone loss (23, 32). Recent systematic reviews of novel nicotine pouches have also identified concerns regarding their impact on oral cellular health; high local concentrations of nicotine and certain flavoring additives (e.g., menthol and fruit esters) have been shown to induce oxidative stress and inflammatory cytokine production in human gingival fibroblasts (7, 23).

3.4.2. Reproductive health and endocrine disruption

The systemic toxicity of smokeless tobacco extends beyond the cardiovascular and oral systems, with profound implications for reproductive health. Evidence from comprehensive reviews indicates that ST use among women of reproductive age is associated with a range of adverse outcomes (33). Nicotine and other toxicants in smokeless tobacco can cross the placental barrier, exerting direct fetotoxic effects. Epidemiological data link maternal ST use during pregnancy to an increased risk of preterm birth, low birth weight, and stillbirth (31, 33). Furthermore, nicotine exposure in utero may predispose the offspring to long-term health challenges, including respiratory dysfunction and altered neurodevelopment (33).

In terms of endocrine function, chronic nicotine exposure can interfere with the hypothalamic-pituitary-gonadal axis, potentially leading to menstrual irregularities and impaired fertility (33). In men, some studies suggest that heavy tobacco use may be associated with reduced sperm quality and histological changes in the reproductive system, although data specifically for oral nicotine pouches remain limited compared to combustible tobacco (24).

3.4.3. Metabolic and nutritional implications

The relationship between oral nicotine use and metabolic health is complex and multifactorial. Systematic evidence suggests that smokeless tobacco use can influence public health nutrition indicators, including Body Mass Index (BMI) and metabolic syndrome prevalence (29). While nicotine is known to suppress appetite and increase resting metabolic rate, heavy ST use (specifically exceeding four cans per week) has been paradoxically associated with a higher risk of developing type 2 diabetes and components of the metabolic syndrome, such as central obesity and insulin resistance (13, 29).

Furthermore, global systematic reviews have highlighted associations between smokeless tobacco use and nutritional deficiencies, particularly in low- and middle-income countries where food insecurity is prevalent (29). The diversion of household income toward tobacco products, combined with nicotine-induced changes in taste perception and dietary habits, can exacerbate malnutrition and anemia in vulnerable populations (29). These findings emphasize that the systemic burden of oral nicotine products is not confined to isolated organs but encompasses a broad spectrum of metabolic and nutritional dysregulation.

4. Discussion

4.1. The "Harm Reduction" paradox and the continuum of risk

The findings of this review highlight a significant public health paradox regarding the classification of oral nicotine products. Within the established "continuum of risk," smokeless tobacco (ST) and novel nicotine pouches (NPs) are consistently rated as substantially less hazardous than combustible cigarettes (11, 12, 13). Systematic assessments using multi-criteria decision analysis (MCDA) suggest that ANDS products carry only a fraction of the overall harm associated with smoking, primarily due to the near-total elimination of combustion-derived toxicants such as tar and carbon monoxide (12, 13). This evidence supports the role of these products as potentially effective tools for tobacco harm reduction (THR) among adult smokers who are otherwise unable to achieve nicotine abstinence (13, 34).

However, the "harm reduction" narrative often obscures the absolute cardiovascular risks associated with sustained nicotine exposure. While the risk of lung cancer and chronic obstructive pulmonary disease (COPD) is markedly reduced, the cardiovascular burden remains significant (17, 21). The high nicotine delivery capacity of modern NPs (up to 20 mg per serving) can produce plasma concentrations that equal or exceed those of traditional cigarettes (7, 14). This sustained systemic exposure contradicts the common perception of these products as "safe" alternatives, as they maintain the user in a state of chronic sympathetic arousal (15, 16).

4.2. Implications for athletes and sports performance

The rising prevalence of oral nicotine use in the sporting community—often referred to as the "snus culture" in professional football and baseball—presents a unique clinical challenge (6, 17). Athletes often utilize these products for their discrete nature and perceived cognitive benefits, such as enhanced focus and appetite suppression (7, 17). However, the physiological reality of nicotine use in a high-performance context is often detrimental.

The sympathomimetic effects of nicotine, including increased heart rate and blood pressure, can lead to elevated myocardial oxygen demand during physical exertion (15, 17). Furthermore, chronic nicotine use has been linked to increased arterial stiffness and impaired endothelial function (15, 20). For athletes, this vascular strain may impair peripheral blood flow and recovery, potentially offsetting any perceived cognitive advantages. The American Heart Association (AHA) has identified the rising use of nicotine pouches among youth and athletes as a "threat of a new addiction," emphasizing that the long-term impact on the cardiovascular integrity of young, physically active individuals remains insufficiently characterized (10, 17).

4.3. Vulnerable populations and the "Gateway" concern

A critical point of discussion is the appeal of flavored "tobacco-free" products to youth and non-smokers. The use of appealing flavors, such as fruit and mint, combined with aggressive social media marketing, has driven the uptake of NPs among populations that would have otherwise remained nicotine-naive (6, 8, 10). The availability of synthetic nicotine further complicates this, as it allows products to bypass traditional tobacco regulations in many regions (2, 9).

There is a growing concern that these products may serve as a "gateway" to nicotine dependence. The efficient pharmacokinetics and high-dose options of modern pouches can lead to rapid addiction (14, 31). In youth, nicotine exposure can have lasting effects on brain development and may increase the likelihood of future transition to other tobacco products (10). Thus, while these products may offer a lower-risk profile for current smokers (34), their introduction into the general market—without strict age and flavoring regulations—presents a net public health risk (17, 35).

4.4 Social Media and Public Policy

The social perception of nicotine pouches is heavily influenced by digital marketing and social media trends. The proliferation of 'nicotine influencers' and the aesthetic appeal of pouch packaging have normalized use among nicotine-naive youth. From a policy perspective, Hartmann-Boyce et al. (2025) [34] point out the ongoing debate regarding the utility of these products in tobacco harm reduction (THR). While they may facilitate smoking cessation for some, the lack of long-term longitudinal data on synthetic nicotine's systemic effects creates a challenge for healthcare providers and regulators who must balance potential benefits for adult smokers against the risk of creating a new generation of nicotine-dependent individuals.

4.5. The Innovation-Regulation Gap: Socio-Policy Implications of 'Tobacco-Free' Branding

The technological transition from botanical tobacco to synthetic nicotine pouches has created a significant challenge for public health governance. As evidenced by the current review, while the cardiovascular strain remains a potent systemic risk, the 'tobacco-free' labeling facilitated by chemical innovation has led to a major shift in social risk perception. This branding effectively lowers the psychological barrier to entry for nicotine-naive individuals, particularly youth and athletes, who may perceive these products as wellness-oriented rather than addictive chemical delivery systems. According to the scoping analysis by Travis et al. (2025) [35] and the regulatory considerations outlined by Berman et al. (2023) [9], this mismatch between rapid technological iteration and existing policy frameworks allows high-concentration nicotine products to proliferate in a 'regulatory gray zone.' For social science and public health policy, the challenge lies not only in mitigating the physiological cardiovascular damage but also in re-evaluating how innovative delivery technologies redefine the social constructs of addiction and harm reduction in the 21st century.

4.6. Limitations and future research directions

This review is limited by the relatively recent emergence of nicotine pouches on the global market. While long-term epidemiological data for Swedish snus are robust (18, 19, 21), longitudinal studies specifically investigating the cardiovascular outcomes of "tobacco-free" synthetic nicotine pouches are still in their infancy. Most current evidence regarding NPs is extrapolated from ST research or based on short-term pharmacokinetic and biomarker studies (3, 7). Future research must prioritize long-term clinical trials to determine whether the absence of tobacco-specific nitrosamines (TSNAs) in NPs translates to a meaningful reduction in cardiovascular mortality compared to traditional smokeless tobacco.

5. Conclusions

The comprehensive synthesis of the current scientific literature regarding smokeless tobacco and novel oral nicotine pouches leads to the following conclusions:

1. Cardiovascular Risk Profile: While oral nicotine products eliminate the inhalation of combustion-derived toxicants, they are not cardiovascularly inert. Chronic use, particularly of high-dose nicotine pouches and Swedish snus, is significantly associated with increased cardiovascular mortality, fatal myocardial infarction, and stroke (18, 19, 21, 26). These outcomes are driven by sustained sympathomimetic activation, resulting in acute hemodynamic stress and long-term vascular damage (15, 16, 17).
2. Pharmacokinetic Intensity: Modern nicotine pouches facilitate rapid and efficient nicotine absorption through the oral mucosa, often achieving peak plasma concentrations and total systemic exposure that meet or exceed those observed in cigarette smokers (7, 14, 29). The use of pH adjusters and synthetic nicotine further enhances the addictive potential and physiological impact of these products (5,9).
3. Oral and Systemic Morbidity: Beyond cardiovascular concerns, oral nicotine use is a definitive risk factor for localized pathologies, including gingival recession, periodontal attachment loss, and mucosal lesions (12, 20, 32). Furthermore, the systemic toxicity of these products extends to adverse reproductive outcomes in women and potential metabolic dysregulation, including an increased risk of type 2 diabetes among heavy users (13, 29, 33).
4. Athletic and Youth Vulnerability: The rising popularity of "tobacco-free" pouches among athletes and youth represents a significant public health challenge. In sports, the perceived performance-enhancing effects of nicotine are often offset by increased myocardial oxygen demand and arterial stiffness (7, 17). In younger populations, flavored products and aggressive marketing risk establishing a new generation of nicotine dependence, potentially serving as a gateway to other forms of tobacco use (6, 10, 35).
5. Regulatory and Clinical Implications: The "harm reduction" potential of these products for adult smokers should not be conflated with absolute safety (11, 12, 34). There is an urgent need for standardized regulation regarding nicotine concentrations, flavor additives, and synthetic nicotine formulations (2, 9). Clinicians, particularly those specializing in sports medicine and cardiology, must incorporate screening for oral nicotine products into routine assessments and prioritize total nicotine cessation as the safest health outcome.

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