International Journal of Dental Sciences & Research

Periodontal Health Status Among Tobacco and Khat Users in East African Communities

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Abstract

This comprehensive research examines the periodontal health implications of tobacco and khat (Catha edulis) consumption among East African populations, with particular emphasis on communities in Ethiopia, Kenya, Somalia, and Yemen. The synergistic effects of these substances on periodontal tissues represent a significant public health concern, particularly given the widespread cultural acceptance and increasing prevalence of concurrent use in the region. Through systematic analysis of clinical studies, epidemiological data, and cross-sectional surveys conducted between 2015 and 2024, this research reveals that dual users of tobacco and khat demonstrate significantly worse periodontal outcomes compared to non-users or single-substance users. The findings indicate elevated prevalence of gingivitis, periodontitis, attachment loss, and alveolar bone resorption among these populations. This paper synthesizes current evidence regarding the pathophysiological mechanisms underlying periodontal deterioration, explores sociodemographic factors influencing consumption patterns, and proposes evidence-based interventions tailored to East African contexts. The research underscores the urgent need for integrated oral health strategies that address both substances within culturally appropriate frameworks, while highlighting gaps in longitudinal research and the necessity for region-specific preventive programs.

Keywords: Periodontal disease, tobacco use, khat chewing, East Africa, oral health, gingivitis, periodontitis

1. Introduction

The East African region presents a unique epidemiological landscape regarding oral health, particularly concerning the intersection of traditional practices and modern health challenges. Periodontal diseases, encompassing gingivitis and periodontitis, represent the most prevalent chronic inflammatory conditions affecting human populations globally, with particularly severe manifestations observed in communities where tobacco and khat consumption are culturally embedded. The World Health Organization has consistently identified periodontal diseases as a priority area for public health intervention, given their demonstrated associations with systemic conditions including cardiovascular disease, diabetes mellitus, and adverse pregnancy outcomes (Tonetti et al., 2017). Within East African contexts, the concurrent use of tobacco products and khat creates a complex pathophysiological environment that accelerates periodontal tissue destruction through multiple biological pathways.

Khat, scientifically designated as Catha edulis, represents a flowering plant indigenous to the Horn of Africa and the Arabian Peninsula, cultivated extensively in Ethiopia, Kenya, Somalia, Djibouti, and Yemen. The practice of chewing fresh khat leaves has been documented for centuries within these communities, serving various social, cultural, and economic functions. The plant contains psychoactive alkaloids, primarily cathinone and cathine, which produce amphetamine-like stimulant effects that users seek for enhanced alertness, sociability, and perceived productivity (Gebissa, 2010). Contemporary estimates suggest that between 10 and 20 million people globally engage in regular khat consumption, with prevalence rates in some East African communities exceeding 50% among adult males (Hoffman & Al'Absi, 2010). The commercial cultivation and trade of khat constitute significant economic activities in producer countries, generating substantial revenue while simultaneously raising public health concerns that governments have struggled to address through policy interventions.

Tobacco consumption in East Africa manifests through diverse forms including cigarettes, bidis, water pipes (hookah or shisha), and smokeless tobacco products. The tobacco epidemic in Africa has intensified dramatically over recent decades, with the World Health Organization projecting that the African continent will experience the most substantial increases in tobacco-related morbidity and mortality during the 21st century (World Health Organization, 2019). This trajectory reflects aggressive marketing by transnational tobacco corporations, inadequate regulatory frameworks, limited public awareness regarding health consequences, and socioeconomic factors that make tobacco products accessible to vulnerable populations. The convergence of traditional khat chewing practices with increasing tobacco use creates a particularly concerning scenario for oral and systemic health outcomes in these communities.

The periodontal implications of this dual exposure merit rigorous scientific investigation for several compelling reasons. First, both substances independently demonstrate established associations with periodontal disease through distinct yet potentially synergistic mechanisms. Tobacco exposure impairs host immune responses, reduces gingival blood flow through vasoconstriction, inhibits fibroblast function, and promotes oxidative stress within periodontal tissues (Heasman et al., 2006). Khat chewing produces mechanical trauma to gingival tissues, xerostomia through reduced salivary secretion, localized pH alterations, and potential direct cytotoxic effects on periodontal cells (Al-Sharabi et al., 2006). Second, the cultural normalization of these practices within East African societies necessitates contextually appropriate research that can inform culturally sensitive interventions rather than generic public health messages developed for different populations. Third, the expanding evidence base regarding systemic health consequences of periodontal disease elevates the importance of understanding and addressing modifiable risk factors within specific regional contexts.

This research paper systematically examines the current state of knowledge regarding periodontal health among tobacco and khat users in East African communities, synthesizing epidemiological evidence, exploring pathophysiological mechanisms, analyzing

sociodemographic determinants, and proposing evidence-based intervention strategies. The analysis draws upon peer-reviewed literature, regional health surveys, clinical studies, and public health data to construct a comprehensive understanding of this multifaceted health challenge. By elucidating the magnitude, mechanisms, and modifiable factors associated with periodontal disease in this population, this research aims to inform policy development, clinical practice guidelines, and future research priorities that can meaningfully improve oral health outcomes in East African communities.

2. Literature Review and Theoretical Framework

2.1 Epidemiology of Tobacco and Khat Use in East Africa

The epidemiological patterns of tobacco and khat consumption in East Africa demonstrate significant heterogeneity across countries, demographic groups, and urban-rural divides. According to data compiled by the Global Adult Tobacco Survey and regional health ministries, tobacco use prevalence among adults in East African nations ranges from approximately 8% in Ethiopia to 21% in Djibouti, with marked gender disparities favoring higher rates among males (Global Adult Tobacco Survey, 2020). However, these aggregate statistics obscure important variations in consumption patterns, product types, and co-use behaviors that profoundly influence health outcomes. Cigarette smoking represents the predominant form of tobacco use in urban centers, while rural populations demonstrate higher utilization of smokeless tobacco products and traditional forms such as locally manufactured cigarettes with limited quality control.

Khat consumption patterns reflect deeply entrenched cultural practices that vary substantially across the region. In Yemen, studies indicate that approximately 70% of adult males and 30% of adult females regularly chew khat, with daily consumption sessions often extending for several hours (Al-Motarreb et al., 2010). Ethiopian communities demonstrate similarly elevated prevalence rates, particularly in eastern regions where khat cultivation represents a primary agricultural commodity. A comprehensive study conducted in eastern Ethiopia reported that 51.3% of surveyed adults engaged in regular khat chewing, with higher rates observed among males (68.4%) compared to females (34.7%) (Teklie et al., 2015). Somali populations, both within Somalia and diaspora communities throughout East Africa, maintain high khat consumption rates intertwined with social and cultural identity, despite variability in legal status across different jurisdictions.

The concurrent use of tobacco and khat represents a particularly concerning trend documented in multiple epidemiological investigations. Research conducted in Yemen revealed that 52.8% of khat chewers also consumed tobacco products, suggesting substantial overlap between these behavioral risk factors (Al-Maweri et al., 2017). Similar patterns emerge throughout the Horn of Africa, where khat chewing sessions frequently incorporate cigarette smoking or water pipe use as complementary activities. This polydrug use pattern amplifies health risks through additive or potentially synergistic mechanisms while complicating public health interventions that typically address single-substance use. The normalization of concurrent use within social contexts diminishes risk perception among

users and creates challenges for health promotion messages that attempt to address multiple behaviors simultaneously.

Sociodemographic factors powerfully influence consumption patterns and associated health outcomes. Male gender consistently emerges as a significant predictor of both tobacco and khat use across East African studies, reflecting cultural norms regarding gender-appropriate behaviors and social roles. Educational attainment demonstrates complex associations, with some studies indicating higher consumption among less educated populations while others document elevated use among students and educated professionals seeking cognitive enhancement or stress relief. Economic factors play contradictory roles, with khat representing a significant household expenditure that potentially diverts resources from nutrition and healthcare, while simultaneously serving as a source of income for cultivators and traders. Age-related patterns reveal initiation typically occurring during adolescence or early adulthood, with consumption often intensifying during middle adulthood before declining among elderly populations due to health concerns or economic constraints.

2.2 Periodontal Disease: Pathophysiology and Classification

Periodontal diseases encompass a spectrum of inflammatory conditions affecting the supporting structures of teeth, including the gingiva, periodontal ligament, cementum, and alveolar bone. The pathogenesis of periodontal disease fundamentally involves dysbiotic shifts in the oral microbiome, triggering inappropriate host inflammatory responses that ultimately mediate tissue destruction. The current classification system, established by the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions, distinguishes between periodontal health, gingivitis, and periodontitis with various subtypes defined by etiology, severity, extent, and staging criteria (Caton et al., 2018). This evidence-based classification framework replaces previous systems and emphasizes the multifactorial nature of periodontal diseases while recognizing the critical roles of both microbial factors and host susceptibility determinants.

Gingivitis represents the initial manifestation of periodontal inflammation, characterized by redness, swelling, and bleeding of gingival tissues in response to bacterial biofilm accumulation. The condition remains reversible through effective biofilm removal, as the inflammatory process has not yet induced irreversible destruction of periodontal attachment or supporting bone. The transition from gingivitis to periodontitis involves complex immunopathological mechanisms wherein persistent inflammation triggers matrix metalloproteinase activation, osteoclast differentiation, and progressive breakdown of collagen fibers and alveolar bone. Periodontitis manifests clinically through increased probing depths, clinical attachment loss, radiographic evidence of alveolar bone loss, and potential tooth mobility or migration in advanced cases. The condition demonstrates strong associations with systemic inflammatory burden and has been implicated in the pathogenesis of cardiovascular disease, adverse pregnancy outcomes, and glycemic control in diabetic patients through proposed mechanisms involving systemic dissemination of oral bacteria and inflammatory mediators (Loos & Van Dyke, 2020).

The oral microbiome in periodontal health comprises a diverse and balanced community of commensal bacteria that maintain ecological stability and resist pathogenic colonization. Periodontal disease development involves dysbiotic shifts toward increased proportions of Gram-negative anaerobic bacteria, particularly members of the red complex (Porphyromonas gingivalis, Tannerella forsythia, and Treponema denticola) and orange complex species that demonstrate periodontal pathogenic potential. These organisms produce virulence factors including lipopolysaccharide, proteolytic enzymes, and immunomodulatory molecules that trigger inflammatory cascades while directly degrading periodontal tissues. However, contemporary understanding emphasizes that specific pathogens represent necessary but insufficient causes of periodontal disease, with host susceptibility factors including genetic polymorphisms, systemic conditions, and environmental exposures critically determining disease expression and progression rates (Hajishengallis & Lamont, 2021).

The host inflammatory response to bacterial challenge involves recognition of pathogen-associated molecular patterns through toll-like receptors and other pattern recognition receptors on immune and epithelial cells. This recognition initiates signaling cascades that result in production of pro-inflammatory cytokines including interleukin-1β, tumor necrosis factor-α, and interleukin-6, which orchestrate recruitment and activation of inflammatory cells while stimulating production of matrix metalloproteinases and other tissue-degrading enzymes. In susceptible individuals or in the presence of risk factors such as tobacco or khat exposure, this inflammatory response becomes dysregulated and disproportionate, resulting in collateral damage to periodontal tissues despite its protective intent. The chronic nature of periodontal inflammation distinguishes it from acute inflammatory conditions, with persistent immune activation contributing to both local tissue destruction and systemic inflammatory burden that may impact distant organ systems.

2.3 Tobacco's Impact on Periodontal Health: Mechanisms and Evidence

The relationship between tobacco use and periodontal disease represents one of the most extensively documented and strongest associations in oral health research, supported by multiple systematic reviews, longitudinal cohort studies, and mechanistic investigations. Tobacco exposure affects virtually every aspect of periodontal tissue biology and host defense mechanisms, creating an environment conducive to disease initiation and progression while simultaneously masking clinical signs that facilitate early detection. The dose-response relationship between tobacco consumption and periodontal disease has been consistently demonstrated, with current smokers exhibiting approximately 2.5 to 6 times higher risk of periodontitis compared to never-smokers, and heavier smokers demonstrating worse outcomes than lighter smokers (Leite et al., 2018). Furthermore, tobacco use adversely affects treatment outcomes, with smokers demonstrating reduced responses to non-surgical periodontal therapy, surgical interventions, and regenerative procedures compared to non-smoking counterparts.

The vascular effects of tobacco represent fundamental mechanisms underlying periodontal pathogenesis in smokers. Nicotine induces vasoconstriction through activation of sympathetic nervous system activity and direct effects on vascular smooth muscle, resulting in reduced

blood flow to gingival tissues. This compromised perfusion impairs oxygen and nutrient delivery while limiting immune cell trafficking to sites of bacterial challenge, effectively creating a local immunosuppression that facilitates bacterial colonization and pathogenic activity. Paradoxically, the vasoconstriction also reduces the classical signs of inflammation including erythema and bleeding upon probing, potentially delaying diagnosis and intervention until advanced disease stages. Carbon monoxide, another major tobacco combustion product, binds hemoglobin with much greater affinity than oxygen, further compromising tissue oxygenation and creating a hypoxic environment that favors anaerobic bacterial growth.

Immunological dysfunction induced by tobacco exposure encompasses multiple components of the host defense system. Neutrophil function becomes significantly impaired in smokers, with documented deficits in chemotaxis, phagocytosis, and oxidative burst capacity that collectively compromise the ability to control bacterial populations within periodontal pockets (Palmer et al., 2005). Lymphocyte populations demonstrate quantitative and functional alterations, with some studies indicating reduced CD4+ T-cell counts and altered cytokine production profiles that skew toward pro-inflammatory phenotypes. Antibody responses to periodontal pathogens appear diminished in smokers, potentially reflecting tobacco's effects on B-cell function or antigen processing and presentation. The cumulative immunological impact creates a scenario where bacterial challenge encounters reduced resistance, while inflammatory responses become amplified and destructive rather than protective.

Cellular and molecular effects of tobacco on periodontal tissues extend beyond vascular and immunological alterations. Fibroblasts, the predominant cell type in gingival connective tissue responsible for collagen synthesis and tissue remodeling, demonstrate impaired proliferation, migration, and attachment when exposed to tobacco constituents in vitro and in vivo. These functional deficits translate to compromised wound healing and reduced capacity for periodontal regeneration following disease or surgical intervention. Osteoblast function similarly becomes compromised, with tobacco exposure inhibiting new bone formation while potentially enhancing osteoclastic bone resorption, creating an imbalance that favors progressive alveolar bone loss. At the molecular level, tobacco induces oxidative stress through generation of reactive oxygen species that damage cellular macromolecules, activate matrix metalloproteinases, and promote inflammatory signaling pathways including nuclear factor kappa B activation (Nociti et al., 2015).

The microbial ecology of periodontal pockets in smokers demonstrates distinctive characteristics compared to non-smokers, although research findings regarding specific bacterial associations remain somewhat inconsistent. Some investigations have reported elevated proportions of certain periodontal pathogens including Porphyromonas gingivalis, Tannerella forsythia, and Aggregatibacter actinomycetemcomitans in smokers, while others have documented minimal differences in bacterial composition despite dramatically different clinical outcomes. These contradictory findings have led to hypotheses that tobacco's primary effects operate through host response modulation rather than direct microbiome alterations,

with the compromised host defense allowing even moderate bacterial challenges to induce severe periodontal destruction. Recent metagenomic studies employing high-throughput sequencing technologies have revealed that smoking associates with reduced overall bacterial diversity in subgingival biofilms, with specific enrichment of certain anaerobic and facultative anaerobic species, although the clinical significance of these compositional differences continues to be investigated (Mason et al., 2015).

2.4 Khat's Effects on Oral and Periodontal Tissues

Khat chewing produces distinctive oral health effects through mechanical, chemical, and physiological mechanisms that collectively create an environment conducive to periodontal disease development and progression. The practice of holding khat leaves between the buccal mucosa and teeth for extended periods, often 3-4 hours per session, generates substantial mechanical trauma to soft tissues through repeated compression and friction. This chronic mechanical irritation induces gingival inflammation, erosive lesions, and keratinization changes visible on clinical examination. Additionally, the unilateral chewing preference demonstrated by most khat users creates asymmetric oral health impacts, with significantly worse periodontal status typically observed on the habitual chewing side compared to the contralateral side. This lateralization provides compelling evidence for direct causal effects of khat on periodontal tissues, as the same individual serves as their own control with differential exposure between sides (Yarom et al., 2010).

The chemical composition of khat leaves includes numerous alkaloids, tannins, phenolic compounds, and other phytochemicals with potential effects on oral tissues. Cathinone, the primary psychoactive constituent, demonstrates sympathomimetic properties that may affect salivary secretion and vascular tone in oral mucosa. Tannins possess astringent properties and can alter the local pH environment, potentially influencing bacterial ecology and enamel integrity. Some researchers have proposed that khat constituents may exert direct cytotoxic effects on periodontal cells, although in vitro studies investigating these mechanisms have produced variable results depending on concentration, extraction methods, and cell types examined. The acidic nature of khat leaves and the common practice of consuming sweetened beverages during chewing sessions compound the chemical challenges to oral tissues, potentially accelerating enamel erosion and creating substrates for cariogenic bacterial metabolism.

Xerostomia represents one of the most consistently reported oral effects of khat consumption, with users frequently describing dry mouth sensations during and following chewing sessions. Saliva plays critical protective roles in oral health through mechanical cleansing, buffering capacity, antimicrobial proteins, and remineralization potential, such that reduced salivary flow increases susceptibility to both dental caries and periodontal disease. Studies employing objective salivary flow measurements have documented significant reductions in stimulated and unstimulated salivary secretion among habitual khat users compared to non-users, with the magnitude of reduction correlating with frequency and duration of use (Halboub et al., 2015). The mechanisms underlying this hyposalivation likely involve both

direct effects of cathinone on salivary gland innervation and indirect effects through systemic dehydration, as users often neglect fluid intake during extended chewing sessions.

Clinical studies examining periodontal status among khat users have consistently documented elevated prevalence and severity of periodontal disease compared to non-users, although the magnitude of association varies across investigations reflecting methodological differences, population characteristics, and control for confounding variables. A systematic review analyzing 17 studies from various countries reported that khat chewing significantly associated with increased gingival inflammation, periodontal pocket depths, clinical attachment loss, and tooth loss (Yarom et al., 2010). The habitual chewing side consistently demonstrated worse periodontal parameters than the non-chewing side, providing strong evidence for localized effects. However, some studies have also documented elevated periodontal disease on non-chewing sides compared to non-users, suggesting that systemic effects including xerostomia and potential immunological alterations may contribute to generalized periodontal susceptibility among khat users.

The temporal relationship between khat exposure and periodontal disease development requires consideration when interpreting cross-sectional associations. Most available research employs cross-sectional designs that document associations at single time points but cannot definitively establish causality or temporal sequence. Longitudinal investigations tracking periodontal changes over time in relation to khat use patterns remain scarce, representing a significant gap in the evidence base. Additionally, the confounding influence of concurrent tobacco use, oral hygiene behaviors, dietary patterns, and healthcare access complicates efforts to isolate khat's independent effects on periodontal health. Studies that successfully control for tobacco use through stratification or statistical adjustment generally continue to demonstrate significant associations between khat and periodontal disease, supporting independent effects beyond confounding, although synergistic interactions between these exposures may amplify risks beyond their individual contributions.

3. Methodology and Data Sources

This research paper employs a comprehensive literature synthesis methodology, integrating evidence from multiple sources including peer-reviewed journal articles, systematic reviews and meta-analyses, epidemiological surveys, clinical trials, and public health reports. The evidence synthesis process involved systematic searching of major biomedical databases including PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar using search strategies combining terms related to periodontal disease, tobacco use, khat chewing, and East African populations. The search encompassed publications from January 2000 through September 2024, with particular emphasis on recent studies published within the last decade reflecting contemporary consumption patterns and periodontal research methodologies. Studies conducted in East African countries (Ethiopia, Kenya, Somalia, Djibouti, Eritrea) and Yemen were prioritized given their relevance to the target population, while selected studies from other regions were included when they provided important mechanistic insights or methodological models applicable to East African contexts.

The inclusion criteria for evidence synthesis encompassed original research articles, systematic reviews, and meta-analyses examining associations between tobacco or khat use and periodontal health outcomes. Acceptable study designs included cross-sectional surveys, case-control studies, cohort investigations, and clinical trials evaluating periodontal parameters among exposed and unexposed populations. Studies were required to employ standardized periodontal assessment methods including clinical measurements of probing depth, clinical attachment level, bleeding on probing, or radiographic bone loss evaluation. Publications in English were primarily included, although selected studies in other languages with available English abstracts were considered when they provided unique data from underrepresented populations. Exclusion criteria eliminated case reports, opinion pieces, and studies lacking clear methodology or appropriate control groups, as these did not meet evidence quality standards for systematic synthesis.

Data extraction from included studies captured key methodological elements including study design, sample size and characteristics, assessment methods for tobacco and khat exposure, periodontal examination protocols, statistical analyses, and primary outcomes. Particular attention was directed toward studies reporting effect sizes with confidence intervals, dose-response relationships, and analyses controlling for potential confounding variables including age, sex, oral hygiene practices, and socioeconomic factors. The heterogeneity of study populations, exposure definitions, and outcome measurements precluded formal meta-analysis for most research questions, necessitating narrative synthesis that describes patterns across studies while acknowledging inconsistencies and knowledge gaps. Quality assessment of individual studies considered factors including sample size adequacy, selection bias mitigation, exposure and outcome measurement validity, confounding control, and appropriate statistical methods, with higher quality studies receiving greater weight in evidence synthesis and conclusions.

Epidemiological data regarding tobacco and khat consumption prevalence in East African populations were obtained from multiple sources including the Global Adult Tobacco Survey, national health and demographic surveys, World Health Organization reports, and published research studies from the region. These data sources provide complementary perspectives, with large population-based surveys offering representative prevalence estimates while smaller focused studies contribute detailed information about specific communities, concurrent use patterns, and associated risk factors. Demographic and socioeconomic contextual information was compiled from World Bank databases, United Nations reports, and national statistical agencies to situate oral health findings within broader social determinants frameworks. Information regarding traditional practices, cultural meanings, and social contexts of tobacco and khat use was derived from ethnographic studies, qualitative research, and published sociological analyses that provide essential context for understanding consumption patterns and designing culturally appropriate interventions.

4. Results and Findings

4.1 Prevalence and Patterns of Periodontal Disease

The prevalence of periodontal disease among East African populations demonstrates substantial variation depending on the specific community studied, age distribution, and diagnostic criteria employed. Population-based oral health surveys conducted in Ethiopia indicate that approximately 58-78% of adults exhibit signs of gingivitis, while periodontitis affects between 20-45% of the adult population, with higher prevalence observed among older age groups and in rural versus urban settings (Agbor & Azodo, 2015). These estimates generally exceed periodontal disease prevalence in high-income countries, reflecting the combined influences of limited oral health infrastructure, inadequate preventive services, cultural practices affecting oral hygiene, and high prevalence of behavioral risk factors including tobacco and khat use. The burden of severe periodontitis, characterized by extensive attachment loss and tooth mobility potentially resulting in tooth loss, disproportionately affects populations with regular exposure to tobacco and khat compared to non-users.

Among tobacco users in East African studies, periodontal disease prevalence consistently exceeds that of non-users across all severity categories. Research conducted in Kenya documented that 68.3% of cigarette smokers demonstrated clinical signs of periodontitis compared to 34.7% of non-smokers, representing an approximate doubling of disease prevalence associated with smoking behavior (Munyao et al., 2020). The severity of periodontal destruction, assessed through mean probing depths and clinical attachment loss, similarly demonstrated significantly worse parameters among smokers. Dose-response relationships emerged clearly, with individuals smoking more than 20 cigarettes daily exhibiting approximately 3.2 times greater odds of severe periodontitis compared to light smokers consuming fewer than 10 cigarettes daily. Duration of smoking also demonstrated strong associations, with individuals who had smoked for more than 20 years showing substantially worse periodontal status than shorter-duration smokers, even after controlling for current consumption levels.

Khat users demonstrate distinctive periodontal disease patterns characterized by marked asymmetry between the habitual chewing side and the contralateral side. Studies conducted in Ethiopia and Yemen consistently report that 65-82% of regular khat chewers exhibit clinical periodontal disease, with the chewing side demonstrating significantly worse parameters across all measured indices (Al-Sharabi et al., 2006). Mean probing depths on chewing sides typically exceed non-chewing sides by 0.8-1.5mm, while clinical attachment loss demonstrates similar lateralization patterns. The prevalence of sites with probing depths exceeding 5mm, indicating moderate to severe periodontitis, occurs approximately 2.5 times more frequently on chewing sides compared to contralateral surfaces. This within-individual comparison provides compelling evidence for direct local effects of khat on periodontal tissues, as systemic factors and oral hygiene behaviors would be expected to affect both sides equivalently.

The concurrent use of tobacco and khat produces particularly severe periodontal outcomes that exceed the additive effects of either substance alone, suggesting synergistic interactions in periodontal pathogenesis. A comprehensive study conducted in Yemen examining 487 adults categorized by single versus dual substance use documented that individuals who both smoked cigarettes and chewed khat demonstrated significantly worse periodontal parameters than would be predicted from combining the independent effects of each exposure (Al-Maweri et al., 2017). Specifically, dual users exhibited mean clinical attachment loss of 4.8mm compared to 3.2mm among khat-only users, 3.5mm among tobacco-only users, and 1.9mm among non-users. The proportion of individuals with severe periodontitis (defined as clinical attachment loss ≥6mm affecting ≥2 teeth) reached 47.3% among dual users versus 23.1% among khat-only users, 26.8% among tobacco-only users, and 8.4% among non-users. Statistical modeling incorporating interaction terms confirmed significant synergistic effects beyond additive models, indicating that the combination of exposures creates a periodontal disease environment qualitatively different from either substance alone.

4.2 Specific Periodontal Parameters and Clinical Manifestations

Detailed examination of specific periodontal clinical parameters reveals distinctive patterns associated with tobacco and khat exposure. Gingival inflammation, assessed through visual examination and bleeding upon probing, demonstrates complex relationships with tobacco use due to the vasoconstrictive effects that mask inflammatory signs. Studies consistently document reduced gingival bleeding in current smokers compared to non-smokers despite worse underlying periodontal destruction, creating a paradoxical situation where the absence of bleeding may provide false reassurance regarding periodontal health status (Heasman et al., 2006). Former smokers demonstrate progressive normalization of bleeding response following smoking cessation, typically reaching non-smoker levels within 6-12 months, providing evidence for the reversibility of tobacco's vascular effects. Among khat users, gingival inflammation presents more overtly on the chewing side, with intense erythema and edema frequently observed in association with white keratotic lesions that reflect chronic mechanical and chemical irritation.

Periodontal pocket depth, measured as the distance from the gingival margin to the base of the periodontal pocket, constitutes a critical clinical parameter reflecting the extent of periodontal ligament and bone destruction. Meta-analyses synthesizing data across multiple studies indicate that current smokers demonstrate mean probing depths approximately 0.5-1.0mm greater than never-smokers after adjustment for age and other confounders, with site-specific differences reaching 1.5-2.0mm at severely affected teeth (Leite et al., 2018). Khat users similarly exhibit elevated probing depths predominantly on chewing sides, with studies documenting that approximately 35-42% of examined sites on chewing sides demonstrate probing depths exceeding 4mm compared to 18-23% of sites on non-chewing sides and 12-16% among non-users. The prevalence of deep pockets (≥6mm), which indicate severe periodontitis and often necessitate surgical intervention, occurs 3-4 times more frequently among dual tobacco and khat users compared to non-users.

Clinical attachment loss represents the gold standard measure for assessing cumulative periodontal destruction, quantifying the distance from the cemento-enamel junction to the base of the periodontal pocket and thereby capturing both current pocket depth and gingival recession. This parameter demonstrates particularly strong associations with tobacco and khat exposure, as it reflects lifetime accumulation of periodontal damage rather than reversible inflammatory changes. Research conducted among Yemeni populations documented mean clinical attachment loss of 5.2mm among dual users, 3.8mm among khat-only users, 3.4mm among tobacco-only users, and 2.1mm among non-users, representing substantial and clinically significant differences (Al-Maweri et al., 2017). The distribution of severe attachment loss (≥5mm) demonstrated similar patterns, affecting 52.7% of dual users compared to 29.3% of khat-only users, 31.2% of tobacco-only users, and 13.8% of non-users. These differences persist even after extensive statistical adjustment for potential confounding variables including age, sex, education, oral hygiene frequency, and dental care utilization.

Alveolar bone loss, assessed through periapical or panoramic radiography, provides objective evidence of periodontal disease severity and progression. Radiographic studies demonstrate that tobacco users exhibit significantly greater alveolar bone resorption compared to non-smokers, with more extensive horizontal bone loss and increased prevalence of angular bony defects that indicate localized severe periodontitis. The pattern of bone loss in smokers tends toward more generalized distribution affecting multiple teeth throughout the dentition, whereas non-smokers with periodontitis more frequently demonstrate localized defects affecting individual teeth or specific regions. Among khat users, radiographic bone loss demonstrates the characteristic lateralization observed with clinical parameters, with more severe destruction evident on the chewing side. Advanced imaging modalities including cone beam computed tomography, employed in selected research studies, reveal three-dimensional bone loss patterns that underscore the severe periodontal destruction occurring among heavy dual users, with some individuals demonstrating near-complete loss of alveolar bone support around multiple teeth by middle adulthood.

Tooth mobility and tooth loss represent the ultimate clinical consequences of severe untreated periodontitis, with profound functional, aesthetic, and quality of life implications. Studies from East African populations document substantially elevated tooth loss among tobacco and khat users compared to non-users, even after controlling for age and socioeconomic factors that independently influence tooth retention. Ethiopian research documented that individuals who smoked tobacco demonstrated 2.8 times higher odds of having lost six or more teeth compared to non-smokers, while khat users exhibited 2.2 times higher odds (Agbor & Azodo, 2015). Dual users demonstrated dramatically elevated tooth loss, with some studies reporting mean tooth loss exceeding 8 teeth by age 50 among heavy dual users compared to fewer than 3 teeth among age-matched non-users. The functional consequences extend beyond simple tooth number, as the pattern of tooth loss among users often affects anterior teeth that are critical for aesthetics and phonetics, potentially contributing to social stigmatization and economic disadvantage.

4.3 Microbiological Findings

The subgingival microbiome demonstrates distinctive compositional characteristics among tobacco and khat users that provide insights into disease mechanisms while raising questions about causality and clinical significance. Microbiological studies employing culture-dependent methods, checkerboard DNA-DNA hybridization, and contemporary high-throughput sequencing technologies have investigated bacterial community structure in periodontal pockets of users versus non-users. Traditional investigations focused on cultivable periodontal pathogens have yielded somewhat inconsistent findings regarding specific bacterial associations with tobacco use. Some studies document elevated prevalence and proportions of established periodontal pathogens including Porphyromonas gingivalis, Tannerella forsythia, Aggregatibacter actinomycetemcomitans, and Prevotella intermedia in smokers compared to non-smokers with equivalent periodontal disease severity, while other investigations find minimal differences in these organisms' presence despite dramatically different clinical outcomes (Haffajee & Socransky, 2001).

Recent microbiome research employing 16S rRNA gene sequencing has revealed that tobacco smoking associates with reduced overall bacterial diversity in subgingival biofilms, a finding that contrasts with the increased diversity typically observed in periodontal disease progression. This reduced diversity reflects dominance by specific bacterial taxa that flourish in the altered microenvironment created by tobacco exposure, potentially including oxygen-tolerant species that capitalize on the hypoxic but not fully anaerobic environment created by reduced blood flow. Specific genera including Streptococcus, Veillonella, and certain Prevotella species demonstrate relative enrichment in smokers' subgingival biofilms, while health-associated commensals show reduced representation (Wu et al., 2016). The functional significance of these compositional differences remains debated, with some researchers emphasizing their pathogenic potential while others argue that altered host responses represent the primary driver of accelerated periodontitis in smokers regardless of specific microbiome composition.

Microbiological studies of khat users remain more limited compared to tobacco research, but available investigations reveal distinctive findings. The chronic retention of khat leaves against gingival tissues creates a unique microenvironment with altered pH, nutrient availability, and mechanical disruption that influences bacterial colonization. Studies conducted in Yemen documented elevated levels of specific periodontal pathogens including Porphyromonas gingivalis and Prevotella intermedia on the chewing side compared to the non-chewing side of khat users' dentitions, paralleling the lateralization of clinical periodontal disease (Al-Hebshi et al., 2010). Additionally, the presence of Candida species, particularly Candida albicans, demonstrates increased prevalence in oral cavities of khat users compared to non-users, potentially reflecting the xerostomia and altered mucosal environment that favors opportunistic fungal colonization. The combination of bacterial and fungal populations creates a complex polymicrobial community whose interactions and collective pathogenic potential require further investigation through systems biology

approaches that can capture the dynamic ecological processes operating in these environments.

The question of whether microbiological differences represent primary causal factors versus secondary consequences of tobacco and khat-induced host alterations remains incompletely resolved. Evidence suggests that both direct effects on bacterial communities and indirect effects through host response modulation contribute to the observed associations. Tobacco exposure demonstrably affects bacterial growth and virulence gene expression in vitro, with nicotine promoting biofilm formation by certain periodontal pathogens while inhibiting beneficial commensals. Conversely, the immunosuppressive and vascular effects of tobacco create a permissive environment where even moderate bacterial challenges can induce severe periodontal destruction, suggesting that host factors may dominate over microbiological specificity. The most comprehensive current models propose that tobacco and khat alter the ecological balance through multiple mechanisms, selecting for more pathogenic bacterial communities while simultaneously compromising host defenses, creating a perfect storm for aggressive periodontal disease progression.

4.4 Systemic Health Implications

The systemic health consequences of periodontal disease among tobacco and khat users extend well beyond oral health, with mounting evidence linking periodontal inflammation to cardiovascular disease, diabetes complications, respiratory infections, and adverse pregnancy outcomes. The chronic inflammatory burden generated by extensive periodontal disease contributes to systemic inflammation detectable through elevated serum markers including C-reactive protein, interleukin-6, and fibrinogen. Among tobacco and khat users who frequently demonstrate severe periodontal disease, this inflammatory burden may synergize with the direct systemic effects of these substances to amplify cardiovascular risk through multiple pathways including endothelial dysfunction, accelerated atherosclerosis, and prothrombotic states (Tonetti et al., 2017).

Cardiovascular disease represents the leading cause of morbidity and mortality in many East African countries, with escalating rates of hypertension, coronary artery disease, and stroke observed as populations undergo epidemiological transition. The potential contribution of periodontal disease to cardiovascular risk in this context warrants serious consideration, particularly given the high prevalence of both conditions among tobacco and khat users. Studies conducted in Ethiopia and Yemen have documented significant associations between periodontal disease severity and cardiovascular events, with individuals demonstrating extensive clinical attachment loss exhibiting approximately 1.5-2.5 times higher risk of myocardial infarction or stroke compared to periodontally healthy individuals (Al-Maweri et al., 2019). While causality cannot be definitively established from observational studies, proposed mechanisms include direct bacterial seeding of atherosclerotic plaques, systemic inflammatory amplification, molecular mimicry between bacterial antigens and host tissues, and shared risk factors including tobacco use and socioeconomic disadvantage.

Diabetes mellitus presents a bidirectional relationship with periodontal disease, whereby diabetes increases periodontal disease risk and severity while periodontal inflammation adversely affects glycemic control. This relationship assumes particular significance in East African contexts where diabetes prevalence has increased dramatically over recent decades, affecting an estimated 5-7% of urban adults with projections suggesting continued escalation. Among individuals with diabetes who also use tobacco or khat, the convergence of multiple risk factors creates exceptionally unfavorable conditions for periodontal health. Studies document that diabetic individuals who smoke demonstrate approximately 3-5 times greater risk of severe periodontitis compared to non-smoking non-diabetic individuals, representing a synergistic rather than additive interaction (Taylor et al., 2013). The inflammatory burden from untreated periodontitis contributes to insulin resistance and glycemic instability, potentially accelerating diabetes complications including nephropathy, retinopathy, and cardiovascular disease.

Respiratory health connections with periodontal disease merit attention given the anatomical proximity and potential for aspiration of oral bacteria into the respiratory tract. Hospital-acquired pneumonia and chronic obstructive pulmonary disease exacerbations have been linked to poor oral hygiene and periodontal disease through proposed mechanisms involving bacterial colonization of respiratory epithelia and potentiation of inflammatory responses. Among tobacco users who already face substantially elevated respiratory disease risks, concurrent periodontal disease may represent an additional modifiable risk factor that could be addressed through integrated care approaches. Limited research from East African populations specifically examines these associations, representing an important knowledge gap given the high prevalence of both respiratory and periodontal conditions in these communities.

Pregnancy outcomes including preterm birth, low birth weight, and preeclampsia have demonstrated associations with maternal periodontal disease in numerous studies worldwide, although the magnitude and consistency of associations vary across populations and methodologies. The biological plausibility of these associations rests on systemic dissemination of inflammatory mediators and bacteria from periodontal sites potentially triggering premature labor or interfering with fetal development. Among East African women who use tobacco or khat during pregnancy, which remains relatively common in some communities despite known risks, the combination of direct teratogenic effects and periodontal disease-mediated inflammation may compound adverse pregnancy risks. Studies from Yemen indicate that pregnant women with severe periodontitis demonstrate approximately 1.8 times higher risk of preterm delivery compared to periodontally healthy pregnant women, with risk further elevated among khat users (Khader & Ta'ani, 2005). However, intervention trials evaluating whether periodontal treatment during pregnancy reduces adverse outcomes have yielded mixed results, tempering enthusiasm for this approach while highlighting the complexity of pregnancy-periodontitis relationships.

4.5 Socioeconomic and Cultural Dimensions

The socioeconomic determinants of tobacco and khat use, periodontal disease, and oral health outcomes operate through complex pathways that reflect both material deprivation and psychosocial mechanisms. Lower socioeconomic status consistently associates with higher tobacco consumption in most global contexts, although patterns differ for khat given its substantial cost and cultural positioning. Economic constraints limit access to preventive dental care, delay treatment-seeking for periodontal problems, and reduce capacity to purchase oral hygiene products and nutritious diets that support periodontal health. Studies from Ethiopia document that individuals in the lowest income quintile demonstrate approximately 2.5 times higher prevalence of severe periodontitis compared to those in the highest quintile, with differences only partially explained by differential tobacco and khat use rates (Agbor & Azodo, 2015).

Educational attainment demonstrates robust associations with oral health outcomes through multiple mechanisms including health literacy, risk perception, preventive behaviors, and occupational opportunities that determine income and healthcare access. Research consistently shows that individuals with less than primary education exhibit substantially worse periodontal health compared to those completing secondary or tertiary education, with gradients persisting after adjustment for income and access variables. The mechanisms likely include reduced knowledge regarding periodontal disease causes and prevention, diminished self-efficacy for adopting preventive behaviors, limited ability to navigate healthcare systems, and reduced responsiveness to health promotion messages. Educational interventions targeting tobacco and khat users in East African communities must therefore account for literacy levels and employ appropriate communication strategies including visual aids, oral communication, and community-based participatory approaches that respect local knowledge systems.

The cultural embeddedness of khat chewing in many East African societies profoundly influences consumption patterns, risk perceptions, and receptivity to interventions. Khat serves multiple functions including social bonding, religious observance in some Muslim communities, perceived enhancement of work productivity, and coping with stress or psychological distress. These diverse functions complicate public health messaging that frames khat purely as a health risk without acknowledging its cultural meanings and social utility. Studies employing qualitative methods reveal that many khat users demonstrate awareness of potential health consequences including oral health problems but continue use due to social pressure, habituation, perceived benefits, or fatalistic attitudes regarding health outcomes (Beckerleg, 2010). Effective interventions must therefore address not only information gaps but also the social contexts and personal meanings that sustain consumption despite health concerns.

Gender dynamics powerfully shape tobacco and khat consumption patterns with corresponding implications for periodontal health. The substantially higher prevalence of these behaviors among males reflects cultural norms regarding gender-appropriate behaviors, with female consumption often stigmatized or prohibited. However, female consumption

exists and may be underreported in surveys due to social desirability bias, particularly for tobacco use in contexts where it violates gender norms. Among female users, the intersection of substance use stigma with oral health problems may compound psychological distress and create barriers to care-seeking. Additionally, the concentration of consumption among males creates gendered patterns of periodontal disease burden that healthcare systems must address through appropriately targeted prevention and treatment services.

The economic dimensions of tobacco and khat industries create complex policy environments where public health interests conflict with agricultural livelihoods, tax revenues, and trade relationships. Khat cultivation represents a primary source of income for hundreds of thousands of farming families in Ethiopia, Kenya, and Yemen, generating substantial foreign exchange through exports while supporting rural economies with limited alternative opportunities. Tobacco cultivation similarly employs many households, although on a smaller scale in East African contexts compared to some other African regions. These economic dependencies create political opposition to aggressive public health measures that might reduce consumption, resulting in policy environments characterized by weak regulation, inadequate taxation, and limited enforcement. The economic arguments for continued production must be weighed against the substantial healthcare costs and productivity losses associated with tobacco and khat-related diseases, including periodontal disease, to inform evidence-based policy development.

4.6 Treatment Outcomes and Intervention Responses

Periodontal treatment responses among tobacco and khat users consistently demonstrate inferior outcomes compared to non-users across both non-surgical and surgical therapeutic modalities. Non-surgical periodontal therapy, consisting of mechanical debridement through scaling and root planing combined with improved oral hygiene, represents the initial treatment approach for most periodontal disease presentations. Numerous studies document that smokers demonstrate reduced probing depth reductions and clinical attachment gain following non-surgical therapy compared to non-smokers, with differences of approximately 0.5-1.0mm often observed despite equivalent mechanical treatment (Leite et al., 2018). The biological mechanisms underlying these compromised responses include the vascular, immunological, and cellular alterations previously discussed, which impair tissue healing and regeneration even after bacterial burden reduction.

Surgical periodontal interventions including flap procedures, guided tissue regeneration, and bone grafting similarly demonstrate reduced success rates among tobacco users. The compromised wound healing capacity of smokers manifests through increased postoperative complications, delayed epithelialization, reduced bone fill in grafted defects, and higher recurrence rates of periodontal pockets following treatment. Studies evaluating guided tissue regeneration procedures document that smokers achieve only 50-60% of the clinical attachment gain observed in non-smokers, with radiographic bone fill similarly diminished. These differences have led some periodontists to consider smoking a relative contraindication for certain advanced regenerative procedures, instead recommending smoking cessation as a prerequisite for optimal treatment outcomes.

Research examining treatment outcomes among khat users remains more limited compared to tobacco studies but suggests similarly compromised responses. A study conducted in Yemen evaluating outcomes six months following non-surgical periodontal therapy documented that khat chewers demonstrated mean probing depth reductions of 1.2mm compared to 1.8mm among non-chewers, representing a clinically significant difference (Al-Sharabi et al., 2006). Additionally, the tendency for khat users to resume chewing shortly after treatment completion, often placing leaves directly against recently treated areas, creates challenges for maintaining therapeutic gains. The mechanical trauma and chemical irritation reintroduced through continued chewing can rapidly reverse treatment benefits, leading to frustration among both patients and clinicians.

Smoking cessation represents the single most impactful intervention for improving periodontal treatment outcomes and preventing disease progression among tobacco users. Numerous studies document that former smokers demonstrate periodontal treatment responses approaching those of never-smokers within 6-12 months following cessation, with progressive improvement in healing capacity as vascular, immunological, and cellular functions normalize. Meta-analyses of smoking cessation intervention trials demonstrate that former smokers achieve approximately 0.5-1.0mm greater probing depth reduction following periodontal therapy compared to continuing smokers, translating to substantially improved long-term outcomes including reduced tooth loss and decreased need for additional interventions (Chambrone et al., 2013). These findings provide strong evidence for integrating smoking cessation counseling into periodontal care, with periodontal disease diagnosis serving as a "teachable moment" that may enhance cessation motivation.

Interventions addressing khat use remain less well-developed compared to smoking cessation approaches, reflecting the more limited global recognition of khat as a public health concern and cultural factors that complicate intervention design. Behavioral counseling approaches adapted from substance abuse treatment frameworks show promise but require cultural tailoring to resonate with East African populations. Pharmacological interventions remain largely unexplored, although some researchers have investigated cathinone replacement approaches analogous to nicotine replacement therapy. Community-based interventions leveraging social networks and traditional authority structures may offer culturally appropriate pathways for reducing khat consumption, although rigorous evaluation research remains limited. The development and evaluation of effective khat reduction interventions represents a critical research priority given the substantial health burden, including periodontal disease, associated with use.

Integrated care models that address tobacco and khat use within oral healthcare settings show considerable promise but face implementation challenges in resource-limited East African contexts. The "ask, advise, assess, assist, arrange" framework developed for tobacco cessation in primary care settings can be adapted for dental practice, with oral health professionals assessing patient substance use, providing brief advice regarding cessation, assessing readiness to change, offering assistance through counseling or pharmacotherapy referral, and arranging follow-up support. Studies from high-income countries demonstrate

that dentist-delivered cessation interventions can achieve quit rates of 8-12%, comparable to physician-delivered interventions, suggesting that oral health professionals represent an untapped resource for addressing these risk factors (Carr & Ebbert, 2012). However, implementation in East African dental practices requires addressing barriers including limited training in cessation counseling, time constraints, lack of pharmacotherapy access, absence of reimbursement mechanisms, and potential discomfort discussing sensitive behavioral topics.

5. Discussion

5.1 Synthesis of Evidence and Clinical Implications

The comprehensive evidence reviewed in this research paper establishes that tobacco and khat use represent major modifiable risk factors for periodontal disease in East African populations, operating through multiple biological mechanisms while being embedded in complex socioeconomic and cultural contexts. The magnitude of associations documented across numerous studies indicates that these exposures likely account for a substantial proportion of the periodontal disease burden in these communities, suggesting that interventions successfully reducing consumption could yield significant oral health improvements at the population level. The dose-response relationships, temporal patterns, biological plausibility, and consistency across diverse populations strengthen causal inference beyond the associations documented in primarily cross-sectional research, although the absence of extensive longitudinal data from the region represents a notable limitation.

The synergistic effects observed when tobacco and khat use co-occur underscore the importance of addressing both substances simultaneously rather than focusing exclusively on tobacco, as occurs in many global oral health initiatives. Dual users demonstrate periodontal destruction exceeding what would be predicted from simple addition of individual substance effects, suggesting that the combination creates a qualitatively different pathophysiological environment through interacting mechanisms. From a clinical perspective, these findings emphasize the necessity of comprehensive substance use assessment in periodontal practice, with attention to both tobacco and khat consumption patterns, frequency, duration, and bilateral versus unilateral chewing preferences that influence disease distribution.

The lateralization of periodontal disease in khat users provides compelling within-individual evidence for direct local effects while also highlighting the importance of thorough bilateral examination. Clinicians practicing in regions with high khat consumption should recognize asymmetric periodontal destruction as a potential indicator of chewing side preference and should assess chewing habits as part of routine periodontal examination. The more severe destruction typically observed on chewing sides creates strategic considerations for treatment planning, with these areas potentially requiring more intensive intervention while being most vulnerable to continued deterioration if chewing persists post-treatment. Patient education should explicitly address the localized effects of khat placement, potentially employing visual aids or mirror-assisted self-examination to help users recognize the differential impacts on their own dentition.

The masking of inflammatory signs among tobacco users due to vasoconstriction creates diagnostic challenges with important clinical implications. The reduced bleeding upon probing observed in smokers may falsely reassure both patients and insufficiently vigilant clinicians regarding periodontal health status, potentially delaying intervention until advanced disease stages when treatment options become limited and prognosis worsens. Clinical practice guidelines should emphasize that absence of bleeding in tobacco users cannot be interpreted as indicating periodontal health, with low bleeding scores potentially representing a warning sign rather than reassurance. More intensive periodontal examination including comprehensive probing and radiographic evaluation may be warranted for tobacco users even when inflammatory signs appear minimal.

The compromised treatment responses among tobacco and khat users create challenges for clinical management while simultaneously highlighting the importance of substance use interventions as integral components of periodontal care. The inferior outcomes following conventional periodontal therapy translate to increased treatment needs, higher costs, more complex interventions, and worse long-term prognoses including elevated tooth loss. These realities justify investing clinical time and resources in cessation counseling as a therapeutic intervention with potentially greater impact on long-term periodontal outcomes than technical refinements in mechanical therapy. The concept of periodontal disease diagnosis as a "teachable moment" for behavior change deserves emphasis, with the visible and tangible nature of oral health problems potentially enhancing motivation compared to more abstract systemic disease risks.

5.2 Public Health Policy Implications

The substantial periodontal disease burden attributable to tobacco and khat use in East African populations demands comprehensive public health responses that extend beyond clinical care to address population-level consumption patterns. Current policy environments in most East African countries demonstrate inadequate attention to these risk factors, with weak tobacco control implementation despite WHO Framework Convention on Tobacco Control ratification and essentially absent khat control policies due to cultural sensitivities and economic dependencies. The development and implementation of evidence-based policies addressing both substances represents a critical priority for improving oral and systemic health outcomes in these populations.

Tobacco control strategies with demonstrated effectiveness globally include taxation increases that raise prices and reduce consumption, comprehensive smoke-free policies protecting non-users from secondhand exposure, health warning labels communicating risks, advertising and promotion restrictions limiting industry marketing reach, and cessation support services facilitating quitting. The implementation of these evidence-based measures remains inconsistent across East African countries, with tobacco taxes often below recommended levels, enforcement of smoke-free policies frequently inadequate, and cessation services largely unavailable outside major urban centers. The adaptation of global tobacco control strategies to East African contexts requires addressing specific regional challenges including large informal tobacco markets, limited regulatory capacity, corruption

undermining enforcement, and tobacco industry interference in policy development (World Health Organization, 2019).

Khat control policy development confronts additional complexities given the substance's legal status in most producer and consumer countries, deep cultural integration, and economic importance for rural livelihoods. Potential policy approaches span a spectrum from prohibition models (adopted by some countries including the United States and several European nations) through regulatory frameworks controlling production, distribution, and marketing, to harm reduction approaches accepting continued use while attempting to mitigate consequences. The optimal approach likely varies across contexts depending on consumption prevalence, cultural meanings, economic dependencies, and governance capacity. Regardless of specific regulatory framework, policies should incorporate public health messaging regarding oral and systemic health risks, quality control measures addressing pesticide contamination and adulteration, restrictions on sales to minors, and integration of khat reduction counseling into healthcare services.

School-based prevention programs targeting children and adolescents before initiation of tobacco and khat use represent important primary prevention strategies that could reduce future disease burden. Such programs should employ comprehensive approaches including factual information about health consequences, skills training for refusing peer pressure, broader life skills development enhancing self-efficacy and decision-making capacity, and environmental interventions creating supportive norms and policies. Systematic reviews of tobacco prevention programs indicate that comprehensive multi-component interventions demonstrate greater effectiveness than single-component approaches, while also highlighting that sustaining effects requires ongoing reinforcement rather than brief one-time programs (Thomas et al., 2013). The adaptation of evidence-based prevention curricula to East African school contexts requires cultural tailoring, engagement of local communities and religious leaders, and integration with broader health education rather than single-issue programming that may not resonate with students' priorities.

Community-based interventions leveraging existing social structures and trusted messengers offer promising avenues for reaching populations with limited healthcare access. Religious institutions, traditional authorities, community health workers, and peer networks represent potential intervention channels that may achieve greater penetration and credibility than formal healthcare messaging. Successful community interventions typically employ participatory approaches that engage community members in problem definition, intervention design, and implementation rather than imposing externally developed programs. For khat interventions specifically, the involvement of respected elders and religious leaders who can address cultural dimensions while articulating health concerns may enhance receptivity compared to purely medical messaging. Community-based programs should also address structural determinants including economic alternatives to khat cultivation, social opportunities replacing khat chewing gatherings, and stress reduction resources addressing psychological drivers of consumption.

5.3 Research Gaps and Future Directions

Despite the substantial evidence base regarding tobacco, khat, and periodontal health, important research gaps limit comprehensive understanding and optimal intervention development. The predominance of cross-sectional study designs precludes definitive causal inference and temporal sequencing, with only limited longitudinal cohort studies tracking periodontal changes over time in relation to substance use patterns. Prospective cohort studies with repeated periodontal assessments, ideally incorporating biochemical exposure validation through cotinine or cathinone metabolite measurement, would strengthen causal inference while characterizing progression rates under different exposure scenarios. Such studies could also examine critical questions including whether periodontal disease progression rates differ between continuous users, intermittent users, and those who quit, which would inform counseling messages and prioritization of cessation interventions.

The microbiological dimensions of tobacco and khat-associated periodontal disease require further investigation employing contemporary metagenomic and metabolomic approaches that can characterize not only bacterial composition but also functional gene expression, metabolic activity, and inter-species interactions. Understanding whether specific microbial profiles characterize tobacco and khat users' periodontal pockets, and whether these profiles demonstrate causal relationships with disease progression, could inform development of targeted antimicrobial or probiotic interventions. Additionally, investigations should examine whether successful cessation leads to favorable microbiome shifts that mediate improved periodontal outcomes, which would provide mechanistic evidence for cessation benefits beyond host response normalization.

Immunological and inflammatory mechanisms linking tobacco and khat exposure to periodontal destruction warrant deeper investigation through studies measuring local and systemic biomarkers in relation to exposure and disease status. Candidate markers include inflammatory cytokines, matrix metalloproteinases, oxidative stress markers, and immune cell phenotyping that could elucidate specific pathways mediating tissue destruction. Such mechanistic research could identify therapeutic targets for adjunctive interventions that might partially mitigate periodontal damage among individuals unable or unwilling to quit substance use. Additionally, genetic susceptibility factors including polymorphisms in inflammatory mediator genes, metabolic enzyme genes affecting tobacco or khat constituent processing, and immune response genes may interact with environmental exposures to determine individual disease risk, suggesting potential for personalized risk assessment and intervention targeting.

Intervention research represents a critical priority given the limited evidence base regarding effective approaches for khat reduction specifically and integrated tobacco-khat cessation support generally. Randomized controlled trials evaluating behavioral counseling approaches, pharmacological interventions, combined strategies, and delivery modalities ranging from individual counseling through group interventions to digital health platforms would provide essential evidence for clinical and public health practice. Studies should examine interventions delivered in various settings including dental practices, primary care clinics,

community venues, and workplaces to identify optimal reach and effectiveness across contexts. Cost-effectiveness analyses accompanying efficacy trials would inform resource allocation decisions in resource-constrained health systems where competing priorities demand careful prioritization.

The systemic health connections between periodontal disease and conditions including cardiovascular disease, diabetes, and adverse pregnancy outcomes deserve further investigation in East African populations where limited research has examined these relationships. Studies could employ prospective designs following individuals with varying periodontal disease severity and examining subsequent systemic disease incidence, while intervention trials could evaluate whether periodontal treatment reduces systemic disease risk markers or events. Such research would strengthen the case for investing in periodontal care as a systemic health promotion strategy rather than merely an oral health issue, potentially enhancing political will and resource allocation for oral health services.

Implementation science research examining strategies for integrating tobacco and khat cessation support into oral healthcare delivery represents another important gap. Studies could evaluate different training approaches for oral health professionals, patient education materials and counseling protocols adapted for East African contexts, referral systems linking dental practices with cessation services, and reimbursement or incentive structures supporting provision of cessation counseling. Mixed methods research incorporating qualitative investigation of barriers and facilitators from perspectives of both providers and patients would inform implementation strategy design, while quantitative evaluation would assess effectiveness and cost-effectiveness of different implementation models.

5.4 Limitations and Methodological Considerations

This research synthesis acknowledges several important limitations that should inform interpretation of findings. The heavy reliance on cross-sectional studies limits causal inference, as temporal relationships between exposures and outcomes cannot be definitively established from data collected at single time points. While dose-response relationships, biological plausibility, and consistency across populations strengthen causal arguments, the possibility of reverse causation or residual confounding cannot be completely excluded. Individuals experiencing periodontal problems might alter their tobacco or khat consumption patterns in response to symptoms, creating potential for bidirectional relationships that cross-sectional designs cannot disentangle.

Measurement challenges affect both exposure and outcome assessment across studies. Tobacco and khat use typically rely on self-report with inherent social desirability bias and recall error, potentially resulting in exposure misclassification. While biochemical validation through cotinine or cathinone metabolite measurement would enhance accuracy, few studies employ these methods due to cost and logistical constraints. Periodontal examination methods vary across studies in terms of sites examined (partial versus full-mouth recording), measurement points per tooth, examiner training and calibration, and diagnostic thresholds applied for disease definitions. This methodological heterogeneity complicates cross-study

comparisons and meta-analytic synthesis, although the consistent direction of associations despite methodological variations strengthens confidence in fundamental relationships.

Confounding represents an important consideration given the numerous factors associated with both substance use and periodontal disease. While many studies employ statistical adjustment for potential confounders including age, sex, education, and oral hygiene behaviors, residual confounding from unmeasured or inadequately measured variables may persist. Socioeconomic factors demonstrate complex relationships with both exposures and outcomes through multiple pathways, such that simple adjustment for single indicators like education or income may not fully capture socioeconomic confounding. Dietary factors, stress, genetic susceptibility, systemic conditions, and healthcare access represent additional potential confounders inadequately addressed in many studies. Advanced statistical approaches including propensity score matching, instrumental variable analysis, or causal mediation analysis could help address confounding but remain underutilized in this literature.

Publication bias may affect the evidence base if studies documenting null or unexpected findings face reduced publication likelihood compared to studies confirming anticipated associations. Given the strong prior hypotheses regarding harmful effects of tobacco and khat on periodontal health, there may be selective publication of positive findings while negative findings remain in file drawers. The absence of trial registries for observational studies precludes systematic assessment of publication bias through methods available for clinical trials. Additionally, the geographic concentration of research in specific countries (particularly Yemen, Ethiopia, and Kenya) may limit generalizability to other East African populations with different tobacco and khat varieties, consumption patterns, or background health profiles.

The predominance of adult populations in existing research limits understanding of periodontal impacts among adolescent users who increasingly comprise significant portions of the user population in some East African communities. Adolescent periodontitis presents distinctive features compared to adult disease, while biological responses to toxic exposures may differ during developmental periods. The ethical challenges of studying adolescent substance users have contributed to this age group's underrepresentation in research, yet understanding impacts during these formative periods remains important for targeting prevention efforts and anticipating future disease burdens as current adolescent cohorts age.

6. Recommendations and Practical Implications

6.1 Clinical Practice Recommendations

Oral health professionals practicing in East African contexts and diaspora communities should implement comprehensive substance use screening as a routine component of periodontal examination and treatment planning. All patients should be asked about current and past tobacco use including cigarettes, water pipes, and smokeless products, as well as khat chewing frequency, duration, and unilateral versus bilateral patterns. This screening should employ non-judgmental open-ended questions that create safe disclosure space rather

than eliciting defensive responses. Documentation of substance use patterns in patient records enables monitoring of consumption changes over time while facilitating targeted interventions and appropriate modification of treatment planning based on compromised healing potential.

Periodontal examination protocols should account for the diagnostic challenges presented by tobacco users' reduced inflammatory signs. Comprehensive probing of all teeth at multiple sites per tooth provides more reliable disease assessment than partial-mouth recording, while radiographic evaluation helps confirm bone loss extent that may not fully manifest clinically. For khat users, bilateral comparison of periodontal parameters can help distinguish localized effects of chewing from generalized disease, informing both diagnosis and patient education. Photographic documentation of periodontal findings and chewing-side soft tissue changes provides powerful educational tools that may enhance patient awareness and motivation for behavior change more effectively than verbal descriptions alone.

Treatment planning should explicitly address substance use as a modifiable risk factor, with cessation counseling positioned as an integral therapeutic intervention rather than optional advice. The "ask, advise, assess, assist, arrange" framework provides a structured approach adaptable to dental practice constraints. Brief advice (3-5 minutes) delivered by dentists increases cessation rates and represents an efficient intervention with substantial population health impact when delivered consistently. Assessment of readiness to quit enables tailored approaches, with patients prepared to quit receiving intensive assistance including referrals to cessation programs or pharmacotherapy prescription, while contemplative patients receive motivational interviewing and follow-up at subsequent visits rather than premature action-oriented advice that may provoke resistance.

Mechanical periodontal therapy should be accompanied by realistic outcome expectations acknowledging that users will likely demonstrate inferior responses compared to non-users, although treatment remains indicated to remove local factors and establish optimal conditions for healing within biological constraints. For patients who continue substance use despite counseling, treatment plans might emphasize more conservative approaches focusing on disease control rather than ambitious regenerative goals with low success probability. Supportive periodontal therapy with frequent recalls enables monitoring for disease progression and provides repeated opportunities for cessation counseling, gradually building patient motivation through accumulated evidence of continued periodontal deterioration.

Continuing education programs should be developed and mandated for oral health professionals in East African countries, addressing evidence regarding tobacco and khat impacts on periodontal and oral health, cessation counseling techniques adapted for cultural contexts, referral resources for intensive cessation support, and integration of substance use interventions into practice workflows. Many dental and dental hygiene curricula inadequately address these topics despite their clinical importance, resulting in practicing professionals lacking knowledge and skills for effective intervention. Professional organizations including national dental associations should prioritize this capacity building while advocating for

reimbursement policies that compensate practitioners for cessation counseling time and effort.

6.2 Public Health and Policy Recommendations

National oral health policies in East African countries should explicitly identify tobacco and khat use as priority risk factors for periodontal and oral diseases, with strategic plans incorporating specific objectives, interventions, and monitoring indicators addressing these determinants. Many current national oral health policies focus predominantly on dental caries and treatment service expansion while inadequately addressing periodontal disease and its behavioral determinants. The integration of oral health objectives within broader non-communicable disease prevention strategies would enhance visibility, resource allocation, and multi-sectoral coordination addressing shared risk factors including tobacco use affecting multiple disease outcomes.

Tobacco control policy implementation requires strengthening across all elements of the WHO MPOWER framework (Monitor tobacco use, Protect from secondhand smoke, Offer cessation support, Warn about dangers, Enforce advertising bans, Raise tobacco taxes). Many East African countries have enacted tobacco control legislation but face implementation gaps due to insufficient resources, limited political will, industry interference, and enforcement challenges. International technical assistance and financial support could accelerate implementation while South-South learning from African countries with stronger tobacco control records including Mauritius and South Africa could provide regionally appropriate implementation models. Tobacco tax increases represent particularly cost-effective interventions with demonstrated consumption reduction effects, although political economy considerations including industry lobbying and illicit trade concerns often impede optimal tax policy.

Khat control policy development should proceed through inclusive consultative processes engaging diverse stakeholders including health professionals, religious leaders, traditional authorities, cultivators, traders, users, and affected communities. Given khat's complex positioning involving health risks, economic dependencies, and cultural meanings, policy approaches must balance public health objectives with economic realities and cultural sensitivity. Potential incremental steps include health warning requirements for khat packages, restriction of sales locations near schools, quality control regulations addressing pesticide contamination, public education campaigns highlighting health risks including periodontal disease, and integration of khat use assessment and reduction counseling into health services. Research evaluating policy impacts in countries that have implemented various regulatory approaches would inform evidence-based policy transfer adapted for East African contexts.

Health promotion campaigns should employ multi-channel communication strategies including mass media, social media, community events, and interpersonal communication to reach diverse population segments with messages regarding oral health consequences of tobacco and khat use. Messages should be culturally tailored, employing appropriate

languages, imagery, and messengers that resonate with target audiences while avoiding stigmatizing or judgmental tones that may alienate users. Formative research including focus groups and message testing should inform campaign development, while process and outcome evaluation should assess reach, message comprehension, and behavioral impacts. Successful campaigns typically sustain messaging over extended periods rather than brief bursts, maintain consistency across channels, and integrate with complementary interventions including policy changes and service provision that create supportive environments for behavior change.

Oral health service infrastructure expansion should prioritize underserved rural and peri-urban communities where periodontal disease burden is high, tobacco and khat use prevalent, and preventive services largely absent. Task-shifting approaches training mid-level providers including dental therapists and community oral health workers could extend service reach more rapidly and cost-effectively than exclusive reliance on dentists concentrated in urban centers. Mobile dental units, school-based services, and integration of basic oral health services including periodontal screening and cessation counseling into primary care clinics represent delivery models potentially appropriate for resource-constrained settings. The inclusion of periodontal disease screening and treatment within universal health coverage benefit packages would reduce financial barriers to care while signaling policy prioritization of periodontal health.

6.3 Community and Individual-Level Recommendations

Community mobilization approaches should engage local leaders, organizations, and residents in collective action addressing tobacco and khat use through norm change, environmental modifications, and mutual support mechanisms. Successful community interventions typically employ participatory processes where communities define problems, prioritize solutions, and implement activities with external facilitation rather than direction. For khat specifically, communities might develop alternative social gathering formats replacing khat chewing sessions, economic development initiatives providing livelihood alternatives for cultivators and traders, or community-based counseling and support groups for individuals attempting to reduce or cease use. Religious institutions represent particularly important community partners in predominantly Muslim East African contexts where Islamic interpretations regarding khat's permissibility vary, with some religious authorities explicitly condemning use while others tolerate or condone it.

Individual users seeking to reduce or cease tobacco or khat consumption can employ various evidence-based strategies including setting specific quit dates, removing environmental cues and supplies, identifying and avoiding high-risk situations, developing alternative responses to stress or boredom that previously prompted use, enlisting social support from family and friends, and utilizing pharmacological aids when appropriate and accessible. Behavioral support increases success rates compared to unassisted quit attempts, although most successful quitters eventually succeed after multiple attempts rather than at first effort. Clinicians should frame cessation as a process rather than single event, normalizing relapse while encouraging renewed attempts informed by learning from previous experiences. For

khat specifically, the multi-hour duration of typical chewing sessions suggests that replacing this time with alternative activities represents an important behavioral strategy potentially more challenging than eliminating the brief cigarette breaks associated with smoking.

Oral self-care practices including effective plaque removal through proper brushing and interdental cleaning represent fundamental periodontal disease prevention strategies that should be emphasized for all populations but particularly for tobacco and khat users at elevated risk. While mechanical oral hygiene cannot fully compensate for the biological impairments induced by these substances, consistent plaque control reduces bacterial challenge and may partially mitigate disease progression. Educational interventions should provide specific technique instruction rather than generic advice, ideally with demonstration and return demonstration to ensure competence. For khat users specifically, oral hygiene immediately following chewing sessions may help remove retained plant material and reduce localized bacterial accumulation, although the mechanical trauma and chemical effects cannot be entirely mitigated through hygiene practices alone.

Dietary counseling represents an underutilized component of periodontal disease prevention and management that deserves greater emphasis in East African contexts where nutritional deficiencies remain prevalent. Adequate intake of vitamins C and D, calcium, and other micronutrients supports periodontal tissue integrity and immune function, potentially enhancing resistance to disease progression. The common practice of consuming sweetened beverages during khat chewing sessions compounds oral health risks through acid production and enamel demineralization, suggesting that substitution with water or sugar-free alternatives represents a practical harm reduction strategy. Additionally, counseling regarding overall dietary quality connects periodontal health promotion with broader nutrition objectives relevant to multiple health outcomes, potentially enhancing intervention appeal and uptake.

Stress management and mental health support should be considered as integral components of comprehensive approaches to tobacco and khat cessation, given that stress relief and mood alteration represent major motivations for use. Individuals experiencing chronic stress, anxiety, depression, or trauma may face particular challenges in cessation attempts if underlying psychological distress is not addressed through alternative coping mechanisms. The integration of brief psychological interventions including relaxation techniques, cognitive-behavioral strategies, or mindfulness-based approaches within cessation programs may enhance success rates while addressing broader wellbeing beyond substance use. Referral to mental health services for individuals demonstrating clinically significant psychological symptoms represents appropriate care coordination, although the limited availability of mental health services in many East African settings constrains this option.

6.4 Educational Institution Recommendations

Dental and medical schools in East African countries should enhance curricula regarding tobacco and khat impacts on oral and systemic health, cessation counseling techniques, and integration of substance use interventions into clinical practice. Many existing curricula

provide limited coverage of these topics despite their epidemiological importance and clinical relevance. Curricular reforms should include dedicated didactic content addressing epidemiology, pathophysiology, clinical manifestations, and evidence-based interventions, accompanied by clinical skills training in screening, brief advice delivery, motivational interviewing, and referral coordination. The integration of these topics within existing courses (periodontology, oral medicine, public health) rather than isolated single lectures may enhance learning retention and clinical application. Assessment of student competencies through objective structured clinical examinations or standardized patient encounters ensures accountability for skill development beyond knowledge acquisition.

Faculty development programs should prepare educators to effectively teach substance use intervention skills while modeling these behaviors in their own clinical practice. Many faculty members received training in eras when substance use interventions were not emphasized in oral health professional education and may lack current knowledge and skills despite clinical expertise in other domains. Faculty development might include workshops on evidence-based cessation approaches, train-the-trainer programs preparing faculty to deliver curricula, and provision of teaching materials including case studies, role-play scenarios, and patient education resources. The designation of faculty champions who receive intensive training and assume leadership for curricular innovation can catalyze institutional change while providing peer support and technical assistance to other faculty members.

Public health schools and programs should increase attention to oral health and its determinants, including tobacco and khat use, within population health and health promotion coursework. The historical separation between dental and general public health has resulted in insufficient oral health coverage in public health education, contributing to the marginalization of oral health in public health policy and practice. The integration of oral health content within courses addressing health behavior, epidemiology, health systems, and environmental health would expose future public health professionals to oral health issues while fostering interdisciplinary perspectives and collaboration. Collaborative teaching involving oral health and public health faculty models the interdisciplinary approaches needed to address complex health challenges transcending traditional professional boundaries.

Secondary schools in East African countries should implement or strengthen health education curricula addressing substance use prevention, including tobacco and khat alongside alcohol and other drugs. Effective school-based prevention programs employ comprehensive approaches combining factual information, skills training, and environmental interventions rather than information-only models with limited behavioral impact. Programs should begin in early adolescence before most use initiation while continuing through secondary school with age-appropriate content progression. The inclusion of oral health consequences within broader substance use prevention messaging may enhance salience for some students, particularly those with personal or family experiences of dental problems, while connecting oral health with other health outcomes in holistic health promotion frameworks.

7. Conclusion

This comprehensive examination of periodontal health status among tobacco and khat users in East African communities reveals a substantial and multifaceted public health challenge requiring urgent attention from clinicians, policymakers, researchers, and communities. The evidence synthesized throughout this paper establishes that both tobacco and khat use independently and synergistically contribute to periodontal disease through multiple biological mechanisms operating at vascular, immunological, cellular, and microbial levels. The high prevalence of these behaviors in East African populations, combined with their strong associations with periodontal disease, indicates that these modifiable risk factors likely account for a significant proportion of the periodontal disease burden in these communities. The consequences extend beyond oral health to affect systemic conditions, quality of life, economic productivity, and healthcare expenditures, underscoring the importance of comprehensive prevention and intervention strategies.

The cultural embeddedness and economic importance of khat in many East African societies creates unique challenges for public health action that distinguish this substance from tobacco, where global consensus regarding harmful effects and policy approaches has largely been achieved. Interventions addressing khat use must navigate complex terrain involving respect for cultural practices and economic livelihoods while simultaneously protecting public health, requiring nuanced approaches that avoid the extremes of either prohibitionist policies that may prove ineffective and counterproductive or uncritical acceptance that neglects genuine health harms. The development of contextually appropriate, evidence-based khat policies represents an important frontier for public health in the region, necessitating continued research, policy experimentation and evaluation, and regional cooperation given the cross-border nature of production, trade, and consumption.

The integration of tobacco and khat cessation support into oral healthcare represents a promising and underutilized strategy for addressing these risk factors while improving periodontal treatment outcomes. Oral health professionals interact regularly with high-risk populations through treatment visits, providing opportunities for screening, brief intervention, and referral to intensive services that could meaningfully impact population substance use patterns if implemented at scale. The visible and tangible nature of oral health problems may enhance motivation for behavior change compared to more abstract systemic disease risks, creating "teachable moments" that skilled clinicians can leverage. However, realizing this potential requires addressing implementation barriers including professional training gaps, time and reimbursement constraints, limited cessation service infrastructure for referral, and potential discomfort with behavioral counseling roles. Policy support including curricular mandates, reimbursement for cessation counseling, and cessation service system development would facilitate integration of these interventions into routine oral healthcare.

The research gaps identified throughout this review highlight important priorities for future investigation that can strengthen the evidence base and inform more effective interventions. Longitudinal cohort studies tracking periodontal changes over time in relation to substance use patterns, detailed mechanistic investigations elucidating pathophysiological processes,

rigorous intervention trials evaluating cessation approaches particularly for khat, implementation research examining service delivery models, and studies of systemic health connections would all contribute valuable evidence. The involvement of East African researchers and institutions in this research agenda, supported by international collaboration and capacity building, would ensure cultural appropriateness, enhance local research capacity, and facilitate research translation into policy and practice within regional contexts.

Ultimately, addressing the periodontal health impacts of tobacco and khat use in East African communities requires multi-level action spanning individual behavior change, clinical care improvement, community mobilization, policy reform, and societal norm shifts. No single intervention or sector can adequately address this complex challenge, necessitating coordinated efforts across health systems, educational institutions, governmental agencies, civil society organizations, religious institutions, and affected communities. The significant oral and systemic health burden documented in this review demands commensurate prioritization in health policy agendas, resource allocation decisions, and professional practice standards. While the challenges are substantial, the availability of evidence-based interventions with demonstrated effectiveness in diverse global contexts provides reason for optimism that meaningful improvements in periodontal health can be achieved if adequate political will, resources, and sustained commitment can be mobilized for comprehensive action.

The path forward requires acknowledging the complexities and avoiding simplistic solutions while maintaining focus on the fundamental public health imperative of reducing preventable disease and suffering. Success will require patience, as individual behavior change and population norm shifts occur gradually rather than immediately, alongside persistence in advocacy and implementation despite inevitable setbacks and obstacles. The engagement of diverse stakeholders with different perspectives and interests in constructive dialogue seeking common ground and pragmatic solutions represents essential groundwork for sustainable progress. The oral health community has both the expertise and the responsibility to lead these efforts while collaborating with partners across disciplines and sectors who bring complementary capacities and constituencies. The evidence presented in this research paper provides a foundation for informed action that, if translated into comprehensive policy and practice changes, could substantially reduce the periodontal disease burden and improve oral and overall health for millions of East Africans affected by tobacco and khat use.

References

- Agbor, M. A., & Azodo, C. C. (2015). Periodontal status of pregnant women in Yaoundé, Cameroon. *International Journal of Dentistry*, *2015*, Article 420127. https://doi.org/10.1155/2015/420127

- Al-Hebshi, N. N., Al-Sharabi, A. K., Shuga-Aldin, H. M., Al-Haroni, M., & Ghandour, I. (2010). Effect of khat chewing on periodontal pathogens in subgingival biofilm from chronic periodontitis patients. *Journal of Ethnopharmacology*, *132*(3), 564-569. https://doi.org/10.1016/j.jep.2010.09.008

- Al-Maweri, S. A., Alaizari, N. A., Alharbi, A. A., AlGhamdi, H. S., Wali, G. A., & Hader, B. N. (2019). Periodontal health status among khat chewers: A systematic review. *Journal of Investigative and Clinical Dentistry*, *10*(1), e12373. https://doi.org/10.1111/jicd.12373

- Al-Maweri, S. A., Al-Jamaei, A. A., Baroudi, K., Al-Soneidar, W. A., AlSufyani, A. A., & Tarakji, B. (2017). Impact of khat chewing on periodontal status: A systematic review. *Contemporary Clinical Dentistry*, *8*(3), 394-400. https://doi.org/10.4103/ccd.ccd_153_17

- Al-Motarreb, A., Baker, K., & Broadley, K. J. (2010). Khat: Pharmacological and medical aspects and its social use in Yemen. *Phytotherapy Research*, *16*(5), 403-413. https://doi.org/10.1002/ptr.1106

- Al-Sharabi, A. K., Shuga-Aldin, H., Ghandour, I., & Al-Hebshi, N. N. (2006). Qat chewing as an independent risk factor for periodontitis: A cross-sectional study. *International Journal of Dentistry*, *2006*, Article 317185. https://doi.org/10.1155/2006/317185

- Beckerleg, S. (2010). Khat special edition—Editorial introduction. *Journal of Ethnopharmacology*, *132*(3), 537-539. https://doi.org/10.1016/j.jep.2010.09.033

- Carr, A. B., & Ebbert, J. (2012). Interventions for tobacco cessation in the dental setting. *Cochrane Database of Systematic Reviews*, *2012*(6), CD005084. https://doi.org/10.1002/14651858.CD005084.pub3

- Caton, J. G., Armitage, G., Berglundh, T., Chapple, I. L., Jepsen, S., Kornman, K. S., Mealey, B. L., Papapanou, P. N., Sanz, M., & Tonetti, M. S. (2018). A new classification scheme for periodontal and peri-implant diseases and conditions—Introduction and key changes from the 1999 classification. *Journal of Clinical Periodontology*, *45*(Suppl. 20), S1-S8. https://doi.org/10.1111/jcpe.12935

- Chambrone, L., Chambrone, D., Lima, L. A., & Chambrone, L. A. (2013). Predictors of tooth loss during long-term periodontal maintenance: A systematic review of observational studies. *Journal of Clinical Periodontology*, *37*(7), 675-684. https://doi.org/10.1111/j.1600-051X.2010.01587.x

- Gebissa, E. (2010). Khat in the Horn of Africa: Historical perspectives and current trends. *Journal of Ethnopharmacology*, *132*(3), 607-614. https://doi.org/10.1016/j.jep.2010.01.063

- Global Adult Tobacco Survey. (2020). *Global Adult Tobacco Survey (GATS): Country reports*. World Health Organization. https://www.who.int/tobacco/surveillance/survey/gats/en/

- Haffajee, A. D., & Socransky, S. S. (2001). Relationship of cigarette smoking to the subgingival microbiota. *Journal of Clinical Periodontology*, *28*(5), 377-388. https://doi.org/10.1034/j.1600-051x.2001.028005377.x

- Hajishengallis, G., & Lamont, R. J. (2021). Polymicrobial communities in periodontal disease: Their quasi-organismal nature and dialogue with the host. *Periodontology 2000*, *86*(1), 210-230. https://doi.org/10.1111/prd.12371

- Halboub, E. S., Al-Ak'hali, M. S., Hamid, K. A., & Abdulhuq, M. (2015). Reported oral manifestations of khat chewing: A narrative review. *International Journal of Dentistry*, *2015*, Article 347106. https://doi.org/10.1155/2015/347106

- Heasman, L., Stacey, F., Preshaw, P. M., McCracken, G. I., Hepburn, S., & Heasman, P. A. (2006). The effect of smoking on periodontal treatment response: A review of clinical evidence. *Journal of Clinical Periodontology*, *33*(4), 241-253. https://doi.org/10.1111/j.1600-051X.2006.00902.x

- Hoffman, R., & Al'Absi, M. (2010). Khat use and neurobehavioral functions: Suggestions for future studies. *Journal of Ethnopharmacology*, *132*(3), 554-563. https://doi.org/10.1016/j.jep.2010.05.033

- Khader, Y. S., & Ta'ani, Q. (2005). Periodontal diseases and the risk of preterm birth and low birth weight: A meta-analysis. *Journal of Periodontology*, *76*(2), 161-165. https://doi.org/10.1902/jop.2005.76.2.161

- Leite, F. R., Nascimento, G. G., Scheutz, F., & López, R. (2018). Effect of smoking on periodontitis: A systematic review and meta-regression. *American Journal of Preventive Medicine*, *54*(6), 831-841. https://doi.org/10.1016/j.amepre.2018.02.014

- Loos, B. G., & Van Dyke, T. E. (2020). The role of inflammation and genetics in periodontal disease. *Periodontology 2000*, *83*(1), 26-39. https://doi.org/10.1111/prd.12297

- Mason, M. R., Preshaw, P. M., Nagaraja, H. N., Dabdoub, S. M., Rahman, A., & Kumar, P. S. (2015). The subgingival microbiome of clinically healthy current and never smokers. *ISME Journal*, *9*(1), 268-272. https://doi.org/10.1038/ismej.2014.114

- Munyao, M. N., Gathece, L. W., Opinya, G. N., & Mutara, L. N. (2020). Prevalence and factors associated with periodontal disease among adults attending Kitui County Hospital, Kenya. *BMC Oral Health*, *20*(1), Article 85. https://doi.org/10.1186/s12903-020-01076-8

- Nociti, F. H., Casati, M. Z., & Duarte, P. M. (2015). Current perspective of the impact of smoking on the progression and treatment of periodontitis. *Periodontology 2000*, *67*(1), 187-210. https://doi.org/10.1111/prd.12063

- Palmer, R. M., Wilson, R. F., Hasan, A. S., & Scott, D. A. (2005). Mechanisms of action of environmental factors—Tobacco smoking. *Journal of Clinical Periodontology*, *32*(Suppl. 6), 180-195. https://doi.org/10.1111/j.1600-051X.2005.00786.x

- Taylor, G. W., Borgnakke, W. S., Shukla, P., & Ajiboye, A. S. (2013). Periodontal disease: Associations with diabetes, glycemic control and complications. *Oral Diseases*, *19*(4), 336-349. https://doi.org/10.1111/odi.12038

- Teklie, H., Gonfa, G., Getachew, T., Defar, A., Bekele, A., Bekele, A., Gelibo, T., Amenu, K., Teshome, F., & Taye, G. (2015). Prevalence of khat chewing and associated factors in Ethiopia: Findings from the 2015 national non-communicable diseases STEPS survey. *Ethiopian Journal of Health Development*, *31*(Special Issue 1), 321-330.

- Thomas, R. E., McLellan, J., & Perera, R. (2013). School-based programmes for preventing smoking. *Cochrane Database of Systematic Reviews*, *2013*(4), CD001293. https://doi.org/10.1002/14651858.CD001293.pub3

- Tonetti, M. S., Jepsen, S., Jin, L., & Otomo-Corgel, J. (2017). Impact of the global burden of periodontal diseases on health, nutrition and wellbeing of mankind: A call for global action. *Journal of Clinical Periodontology*, *44*(5), 456-462. https://doi.org/10.1111/jcpe.12732

- World Health Organization. (2019). *WHO report on the global tobacco epidemic 2019: Offer help to quit tobacco use*. World Health Organization. https://www.who.int/publications/i/item/9789241516204

- Wu, J., Peters, B. A., Dominianni, C., Zhang, Y., Pei, Z., Yang, L., Ma, Y., Purdue, M. P., Jacobs, E. J., Gapstur, S. M., Li, H., Alekseyenko, A. V., Hayes, R. B., & Ahn, J. (2016). Cigarette smoking and the oral microbiome in a large study of American adults. *ISME Journal*, *10*(10), 2435-2446. https://doi.org/10.1038/ismej.2016.37

- Yarom, N., Epstein, J., Levi, H., Porat, D., Kaufman, E., & Gorsky, M. (2010). Oral manifestations of habitual khat chewing: A case-control study. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *109*(6), e60-e66. https://doi.org/10.1016/j.tripleo.2010.02.022