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Vaping and E-Cigarettes: Emerging Trends and Potential Impact on Periodontal Health- A Narrated Review

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Review

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ABSTRACT

Electronic cigarettes (e-cigarettes) are battery-powered devices designed to vaporize and heat a liquid solution that typically includes nicotine. Despite recent advances, however, modern vapes have achieved the 50-year-old dream of imitating smoking while reducing the number of toxins, and future advances are bound to disrupt the current generation of electronic cigarettes. Vaping has been considered a leading risk factor for different oral pathologies and conditions, including oral cancer and periodontitis. The rapid growth in the popularity of vaping has resulted in diverse potential health consequences, many of which have the potential to affect periodontal health. Some studies indicate potential benefits in vaping concerning transitioning from traditional smoking cigarettes to vaping because of a reduced prevalence of established diseases, while others report an increased risk of periodontitis among e-cigarette smokers. Additionally, dental practitioners should be aware of the challenges associated with oral health among vape patients and educate them on the potential deterioration effects while conducting regular assessments of smoking habits.

Keywords: Electronic Cigarettes, Oral Health, Vaping, Periodontitis, Nicotine, Public Health

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Introduction

Electronic cigarettes, or e-cigs, also known as electronic nicotine delivery systems, alternative nicotine delivery systems, e-hookahs, mods, vape pens, vaporizers, vapes, and tank systems,[1]are battery-powered devices designed to vaporize and heat a liquid solution that typically includes nicotine.[2] Compared to tobacco products such as cigarettes, e-cigs, and vapes are not a single product but rather a diverse category.[3] Nonetheless, all e-cigs must share the same core components: a battery to generate heat, a metal heating element, and a liquid solution (Figure 1). The substance produced by an e-cigarette is aerosolized and inhaled via a process known as vaping. It should be noted that vaping is fundamentally distinct from smoking. The main difference is the working temperature: in the first case, it is more than 1000 °F, while in the second case, it reaches between 250 and 500 °F. In this regard, the level of toxicity and the components of the resulting substances are very different and more complex in the case of smoking.[2]

Vaping in general and e-cigarettes in particular have evolved significantly since their inception, influencing how people consume tobacco and nicotine. Although considered a contemporary phenomenon, e-cigarette use has a long history, and it has progressed over the years to develop smoke-free replacements for conventional cigarettes. Joseph Robinson developed the earliest recorded concept of an electronic cigarette in his 1930 invention "Mechanical Atomizer for Smokeless Non-Tobacco Cigarette". His device was designed to produce tobacco flavor and nicotine without combustion or inhalation, even though he never made a working prototype. In 1963, Herbert A. Gilbert developed the "Smokeless Non-Tobacco Cigarette," which closely resembled e-cigarettes as they are currently designed. Despite this development, it did not achieve significant commercial success due to a lack of funds.

Throughout the 1970s to 1990s, sporadic attempts to commercialize smoke-free nicotine consumption continued independently of any health concerns, fueled solely by entrepreneurship. Smoke-free nicotine consumption was revolutionized in the early 2000s by Hon Lik's patented e-cigarette in 2003, which delivered nicotine cleanly and conveniently in a cartridge and made smoking popular in the 2010s. Despite recent trends, however, modern vapes have achieved the 50-year-old dream of imitating smoking while reducing the number of

toxins, and future advances are bound to disrupt the current generation of e-cigarettes.[4]

Considering that many societal developments have led to unfavorable consequences for oral health, the increasing popularity of vaping may have similarly dangerous effects on periodontal tissues. Given that the relationship between cigarette smoking and periodontal disease has been extensively studied, it is appropriate to replicate the described effect on vaping.[5] For many decades, tobacco smoking has been considered a leading risk factor for different oral pathologies and conditions, including oral cancer and periodontitis. Dentists and other dental professionals are responsible for developing effective treatment plans and providing necessary guidance and support aimed at helping smoking patients consider the possibility of smoking cessation.[6] Studies have shown that tobacco smoking triggers a proinflammatory effect by stimulating the release of certain cytokines and reactive oxygen species, which destroy periodontal tissues.[7,8] Therefore, it is crucial to consider and compare smoking- and vaping-related factors that are similar in terms of their effects on periodontal health. Such studies may shed light on the most appropriate ways to advance dental practice and public health to promote oral health and eliminate relevant diseases.

This review aims to analyze the current evidence, explore emerging trends, and discern the potential implications of vaping and e-cigarettes for periodontal health.

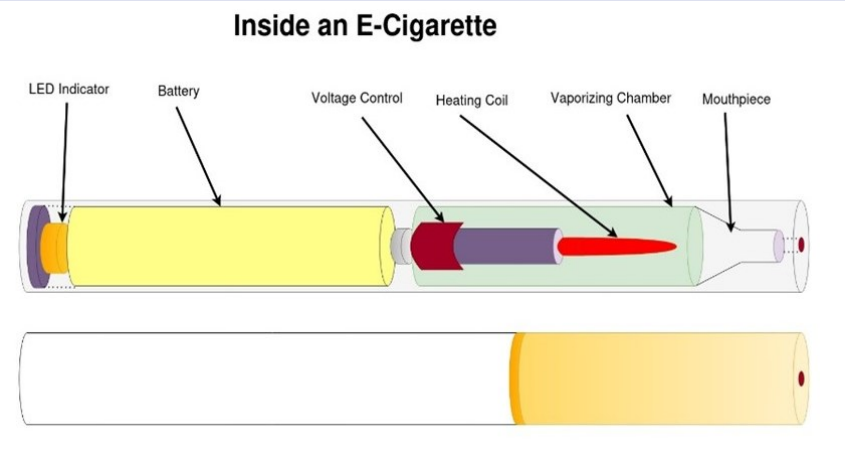

Figure 1. Components of e-cigarettes

Vaping and E-Cigarettes:

Vaping devices are battery-operated machines used to inhale aerosols containing nicotine, flavorings, and other chemicals, even those with no nicotine. These devices include a variety of sizes and designs, including forms that resemble tobacco cigarettes, cigars or pipes, and everyday objects such as pens or USB memory sticks.[9]

E-cigarette devices are characterized by these four generations, which have inherent characteristics and operational peculiarities. The first generation, or cigalikes, "vape sticks," were designed for smokers to avoid the use of classic cigarettes. They may look like cigars or pipes and be similar to pens of a smaller size and minor adjustments, the so-called pen style. The second generation of e-cigarette devices includes devices with clearomizers, a transparent cartridge with e-liquid, and an atomizer nestled around a slender battery. They have a cylindrical shape and are beneficial in size, resembling pens, which is why machines of this generation are often referred to as tank systems. The volume of e-liquid is larger in comparison with the specified systems of the first generation. Third-generation machines are predominantly sold as vapor devices marketed for "vaping". They boast a diverse set of designs, many of which are square or rectangular, and feature choices for customization and rebuildable atomizers and batteries. These systems are also known as "mods," which allow users to experiment with different configurations or create their own. Fourth-generation machines known as "pod mods", vary in size, shape, and color and with extremely long charge time (Figure 2). The variations in design significantly impact aerosol production and composition, influencing the distribution and size of aerosol particles. Moreover, differences in e-liquid chemistry and nicotine intensity determine the amount of aerosol makeup delivered to users.[10]

E-liquids are made up of humectants and flavorings, some containing nicotine (Figure 3).[11] After being evaporated by the atomizer, the aerosol imitates smoking tobacco and is claimed to be free of adverse effects. However, heating during the vaporization process can cause the production of new degradation substances that can be harmful. E-liquids also vary in nicotine content, the only addictive ingredient in tobacco that remains commercially available; even some products that are labeled as not containing nicotine may have been found to contain this component. As a result, e-cigarettes have been claimed to be a smoking cessation aid since nicotine-

containing e-liquids can alleviate smoking cravings. However, the effectiveness of this approach has yet to be proven.[12]

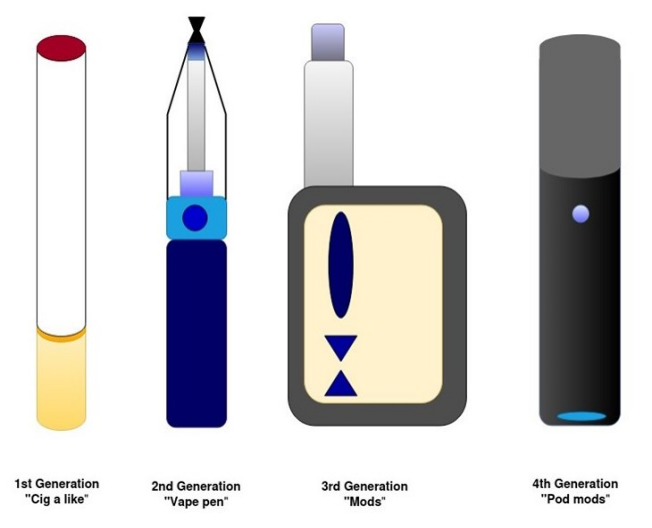

Figure 2. Generations of e-cigarettes

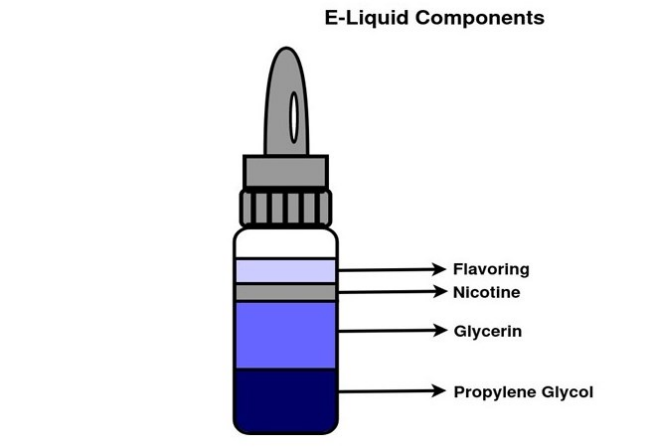

Figure 3. Components of e-liquid

Influence of E-Cigarettes on Systemic Health, Genetics, and Host Response:

E-cigarette-derived nicotine contributes to periodontal disease and lung inflammation by impairing fibroblast function, delaying wound healing, and reducing cell viability.[13,14] Direct exposure to e-vapor damages periodontal ligament and gingival fibroblasts, leading to extracellular matrix protein carbonylation and DNA damage.[13] Additionally, vaping weakens innate immune responses by reducing neutrophil chemotaxis, reactive oxygen species production, and phagocytosis, increasing susceptibility to bacterial infections.[15] Chronic inhalation alters airway and systemic inflammation, heightening the risk of inflammatory diseases and disrupting host-microbial interactions, which can trigger gingivitis and periodontitis.[16,17]

E-cigarette aerosols alter the oral microbiome, enriching periodontal disease-associated pathogens and accelerating disease progression.[18] Certain e-liquid additives, such as cinnamaldehyde, have immunosuppressive effects that impair respiratory immune cell function and may contribute to periodontal tissue damage.[19]

Nicotine addiction is influenced by genetic predisposition, neurotransmitter pathways, and environmental factors. Genetic links between alcohol consumption and nicotine dependence suggest a shared basis for substance use disorders.[20,21] Polygenic risk scores (PRSs) indicate a higher likelihood of e-cigarette use, particularly among ex-smokers and non-smokers.[22]

Vaping also affects epigenetic aging similar to traditional smoking. E-cigarette users exhibit accelerated lung epigenetic aging, marked by significant methylation

loss in Long Interspersed Nuclear Element-1 (LINE-1) repeat elements and reduced global DNA hydroxymethylation (5-hmC) levels.[23,24] Acute vaping exposure can alter gene expression related to DNA repair and cancer pathways, including the upregulation of the tumor suppressor gene Tumor Protein P53 (TP53).[25] Both vaping and smoking dysregulate immune response and mitochondrial genes, critical for inflammation and cellular function.[26]

Effects of Vaping on Periodontal Health:

The periodontium, which consists of the cementum, periodontal ligament (PDL), alveolar bone, and gingival tissue, provides support and defense against oral pathogens and aids in tooth attachment to bone.[27] Gingivitis and periodontitis are inflammatory conditions that impact the periodontium and are marked by gingival inflammation, bleeding, and eventual loss of tooth-supporting structures.[28] Smoking and type I and type II diabetes increase the risk of periodontal disease.[29] Additional factors, such as poor oral hygiene, stress, hereditary predisposition, misaligned teeth, immune deficiencies (e.g., AIDS- Acquired Immune Deficiency Syndrome), defective fillings, medications causing dry mouth, ill-fitting bridges, and hormonal changes in females due to pregnancy or oral contraceptive use, also contribute to the development and progression of periodontal diseases.[30]

Vaping potentially triggers an inflammatory response in the gingiva which could contribute to the onset and progression of periodontal disease. This response may involve the release of inflammatory cytokines and alteration of the periodontal microflora, thus impacting the overall health of the gingiva and surrounding tissues. Nicotine, a key constituent of e-cigarettes, adversely affects the gingiva and periodontium through various mechanisms. It induces vascular alterations, impairs neutrophil function, reduces Immunoglobulin G (IgG) production, inhibits lymphocyte proliferation, increases the prevalence of periodontal pathogen, obstructs pathogen elimination during mechanical therapy, and disrupts fibroblast attachment and function. Furthermore, nicotine exposure triggers negative local effects on cytokine and growth factor production, exacerbating periodontal damage and impeding periodontal tissue repair processes.[31] Exposure to e-cigarette aerosols has been shown to disrupt the composition of the oral microbiome, impeding the growth of beneficial commensal bacteria while facilitating the formation of biofilms by opportunistic microorganisms. This alteration promotes the colonization of the oral cavity by pathogenic bacteria (Figure 4).[32]

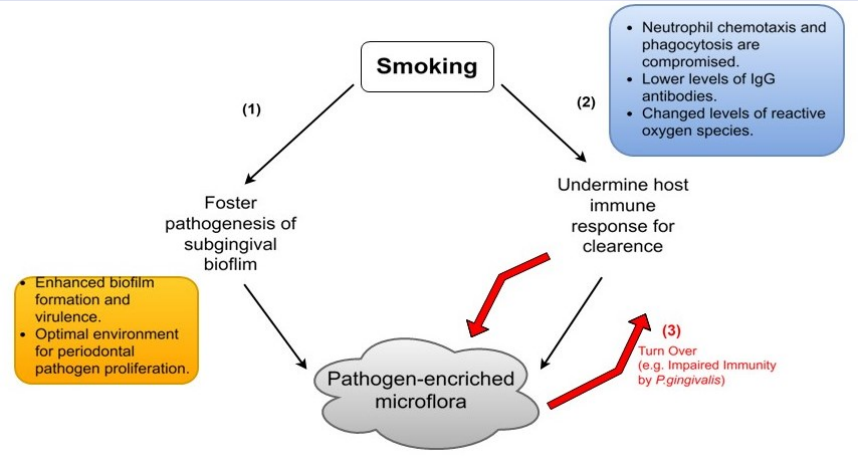

Figure 4. An outline is presented in a schematic illustration of the potential mechanism that contribute to the negative effects of smoking on subgingival microflora.
1- Smoking can promote a pathogen-enriched subgingival microflora
2- Inhibits the host immune response necessary for bacterial clearance
3- Periodontal pathogens can manipulate the host's immune response, leading to a detrimental cycle

Mechanisms of Periodontal Damage by Vaping

Vaping has been shown to have adverse effects on oxidative stress markers and inflammatory cytokines, similar to traditional cigarette smoking. Such effects may contribute to impaired wound healing and inflammation within periodontal tissues.[33] Vaping and smoking alter the host response to bacterial plaque, resulting in modifications in the gingival inflammatory response, such as heightened gingival bleeding and increased gingival crevicular fluid volume.[34] Nicotine, present in vaping and oral nicotine pouches, can directly or indirectly disrupt periodontal tissues by activating nicotinic acetylcholine receptors, elevating cellular reactive oxygen species, and dysregulating microRNA (miRNA) expression. These processes collectively contribute to periodontal inflammation.[35] Vaping has harmful impacts on periodontal ligaments and gingival fibroblasts, leading to oxidative stress, DNA damage, and inflammation. Such

consequences hinder tissue remodeling, consequently disturbing the regular turnover and maintenance of periodontal tissues, thus compromising wound healing and tissue regeneration (Figure 5).[36,37]

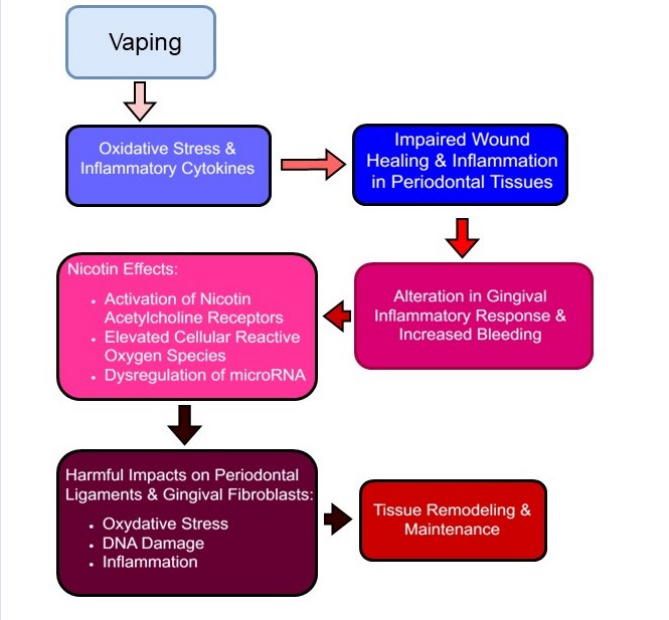

Figure 5. Mechanisms of Periodontal Damage by Vaping

Clinical Studies on Vaping and Periodontal Health

Epidemiological evidence has shown that vaping is linked to an increased risk of gingivitis periodontal disease, and a decrease in the antioxidant capacity of saliva.[7,38] In addition, a comprehensive review, and meta-analysis of the impacts of electronic cigarettes versus conventional cigarettes on periodontal health found less possibility of bleeding on probing seen in electronic cigarette consumers relative to smokers.[39] Furthermore, according to a study by South Korean adults, there was a statistically significant increase in the prevalence of periodontal disease linked with both vaping and smoking, suggesting that vaping may not be a safer alternative to smoking in terms of periodontal health.[40]

A longitudinal study was conducted to evaluate the effect of e-cigarettes on periodontal health. After 6 months, it was found that e-cigarette smokers had worse clinical attachment loss (CAL) compared to non-smokers, indicating a potential negative impact on periodontal health.[41] However, a clinical observational pilot study reported a progressive improvement in periodontal indices and general health perception among smokers who switched to e-cigarettes, suggesting a positive impact on periodontal and general health status.[42] There was a remarkable improvement in gingival inflammation and reduction in plaque accumulation. Another study compared periodontal parameters and self-perceived oral symptoms among cigarette smokers, e-cigarette vapers, and nonsmokers. It was found that periodontal and self-perceived oral symptoms were poorer among cigarette smokers than among vaping individuals and nonsmokers.[43]

The composition of certain vaping solutions, especially those with sweet flavors, may be highly cariogenic and used to attract young people, posing a risk to periodontal health.[5] A cross-sectional study demonstrated a notable variance in caries risk levels between individuals who use e-cigarettes or vapes and those who do not, with users having a heightened susceptibility to caries development.[44]

A study on the impacts of smoking, vaping, and smoking cessation on oxidative stress markers, proinflammatory cytokine levels, GCF volume, and periodontal clinical parameters has demonstrated that both traditional cigarette smoking and vaping exhibit adverse effects on markers of oxidative stress and inflammatory cytokine, suggesting possible implications for long-term periodontal health. The smoking cessation group exhibited a higher volume of GCF and increased IL-8 levels, along with lower TNF-α levels, compared to the e-cigarette group and the traditional cigarette group. The authors concluded that vaping e-cigarettes does not have the adverse effect on GCF and IL-8 levels that smoking traditional cigarettes does but also does not offer any beneficial effect in stimulating IL-8 production. It could also be acknowledged that vaping e-cigarettes have a less negative impact on periodontal inflammation due to reduced neutrophil accumulation and a lowered cellular immune response.[33]

Comparative Studies on different types of E-cigarettes and Differences in Their impact on Periodontal Response

E-cigarettes, including electronic nicotine delivery systems (ENDS), vaping devices, and heat-not-burn tobacco products, vary in design and nicotine delivery,

influencing their impact on periodontal health.[45–47] Studies indicate that while all e-cigarette types contribute to periodontal disease, their effects differ in severity compared to traditional cigarettes. E-cigarette users face a higher risk of periodontal disease than nonsmokers, though their risk remains lower than that of conventional smokers.[13,46,48–50]

The aerosols produced by e-cigarettes contain toxic components that adversely affect oral health, contributing to dental caries, periodontitis, and alterations in the oral microbiome and saliva composition.[51–53] Additionally, variations in e-cigarette design influence the degree of biofilm formation, microbial adhesion, and inflammatory response, leading to differences in periodontal disease severity.[51] Although e-cigarettes may cause attenuated inflammatory signs compared to conventional tobacco, their impact on periodontal and peri-implant health remains detrimental, increasing oxidative stress and inflammatory cytokine production.[47,51] The presence of elevated interleukin-1β and tumor necrosis factor-α in saliva among e-cigarette users further suggests a pro-inflammatory response, highlighting the periodontal risks associated with these devices.[53,54]

Potential Public Health Implications

Given the widespread prevalence of vaping, particularly among young people, it becomes imperative to launch awareness campaigns aimed at informing individuals about the associated risks and potential harms.[38] E-cigarettes have been heavily promoted as a means to quit smoking and as a supposedly healthier, cheaper, and more socially acceptable alternative to traditional cigarettes.[55] Nevertheless, the future implications of e-cigarettes on health remain uncertain, with apparent links being established between vaping and periodontal disease, peri-implant complications, oral cancer, and mental health disorders.[56] It is essential for dental professionals to acknowledge the impact of traditional smoking and to comprehend both the risks of e-cigarettes on oral health and their advantages when utilized in smoking cessation.[5] Patients should be regularly queried about their vaping behaviors during their medical-dental history assessments, with the recommendation that the use of e-cigarettes be recorded as one of the risk factors contributing to a patient's susceptibility to cavities.[44]

Various regulatory strategies are being implemented worldwide for e-cigarettes, encompassing limitations on product sale, manufacturing, importation, distribution, use, product design, advertising, and marketing controls.[57,58] Some commonly observed measures include setting a minimum purchase age, imposing indoor-use prohibitions, and regulating marketing activities.[57] While only a few countries impose taxes on e-cigarettes, the evidence regarding the adverse effects and advantages of e-cigarette use remains inconclusive.[58] The limited and inconclusive scientific data on the long-term health impacts of e-cigarette use present challenges for regulators in making well-informed decisions. Factors such as the novelty of e-cigarettes, perceptions of harmlessness, diverse flavor options, and peer influence contribute to the appeal of e-cigarettes among young people, underscoring the difficulties faced by regulators in ensuring appropriate access and marketing practices for this vulnerable demographic.[59] Constraints imposed by international and European rules on regulators in the policy space of e-cigarette regulation present additional challenges in formulating effective regulatory measures.[60]

Health risks and environmental concerns associated with passive vaping.

Passive exposure to secondhand vape aerosols, commonly known as passive vaping, has been demonstrated to carry potential health risks. Research indicates that inhaling these aerosols may have adverse effects on respiratory health, causing inflammation and potential harm, particularly in individuals with preexisting respiratory conditions.[61–64] Research conducted on passive exposure to vaping in individuals with chronic obstructive pulmonary disease (COPD) revealed that this exposure has a detrimental impact on surfactant protein-A (SP-A) levels in exhaled breath and triggers inflammation, suggesting potential risks associated with passive vaping.[61] While the impact of being passively exposed to e-cigarette vapor could potentially result in negative health outcomes, the risk is believed to be lower than that associated with passive exposure to traditional cigarette smoke.[62] Studies have revealed that chemical components found in e-cigarette aerosols, such as volatile organic compounds (VOCs), particulate matter, and toxic substances, are detectable in both active and passive vaping settings.[65–68]

While the levels of harmful compounds emitted from vaping are generally lower than those from tobacco smoking, measurable toxic elements and VOCs are still present, prompting concerns about potential health risks for both e-cigarette users and bystanders.[67,68] In indoor environments, the use of electronic cigarettes has been shown to produce high levels of fine and ultrafine particles, comparable to those emitted by tobacco cigarettes (Figure 6). This could have significant implications for indoor air quality and public health.[69,70] Studies indicate that electronic cigarette aerosols can contribute to elevated levels of air pollutants indoors, potentially impacting the health of bystanders, especially in poorly ventilated areas.[68,69] Additionally, e-liquid leakage from vaping devices presents a significant health concern. Leakage can result in direct skin contact with nicotine and other toxic substances, leading to irritation and increased systemic absorption.[71] Leaked e-liquids can also evaporate, releasing harmful chemicals such as formaldehyde, acetaldehyde, aluminum, copper, and lead into the air, degrading indoor air quality and increasing the risk of toxic inhalation.[72,73] Studies have already shown that e-cigarette aerosol exposure contributes to oxidative stress, DNA damage, and mitochondrial dysfunction in lung fibroblasts, raising concerns about prolonged exposure due to leakage. Furthermore, nicotine and chemical residues from leaked e-liquids can deposit on

oral tissues, increasing the risk of periodontal diseases by promoting inflammation, plaque accumulation, and bone loss.[74] Environmental contamination is another concern, as leaked liquids may leave behind harmful residues on surfaces, posing risks, especially to children and pets.[75] Addressing design flaws in vaping devices and raising awareness about proper handling and storage are essential to minimizing these risks.[76]

Given the growing popularity of vaping among young people, there is also a growing concern regarding the social and environmental repercussions of secondhand vaping. Nevertheless, it is crucial to acknowledge that the lasting consequences of secondhand vaping remain incompletely understood, necessitating additional research to gain a deeper insight into the potential health, safety, and environmental ramifications of vaping.[63,67]

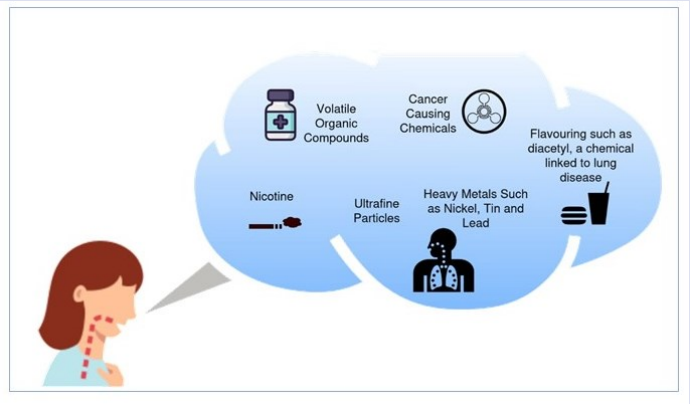

Figure 6. Health risk and environmental concerns associated with passive vaping

Future Directions and Research Needs

The advent of electronic nicotine delivery systems (ENDSs), such as e-cigarettes, has sparked a surge in research endeavors aimed at comprehending their effects on public health and individual users.[77] The evolving landscape of e-cigarette research highlights the necessity for further investigations employing experimental, intervention, and longitudinal methodologies to elucidate the potential repercussions of e-cigarette usage on smoking cessation, initiation, and public health.[78]

Longitudinal studies play a pivotal role in comprehending the trends in e-cigarette and cigarette usage over an extended period. Studies indicate that factors such as daily vaping, non-tobacco flavors, and customizable e-cigarette devices can significantly affect shifts in usage patterns, thus affecting both smoking cessation and exclusive e-cigarette use.[79,80]

Mechanistic investigations are essential for comprehending the possible health hazards and advantages of e-cigarettes. Various studies have pointed out the diversity in e-cigarette product choices, such as significant differences in product structure and component operation, which can impact nicotine delivery and potential product dangers.[81,82] It is vital to grasp the elements that impact puffing patterns to establish standardized protocols for examining aerosol emissions and overseeing e-cigarettes. The quantity of aerosol produced can be influenced by product design, vaping patterns, and device configurations.[83]

Research needs outlined in the literature encompass standards for assessing the components and emissions of e-cigarettes, biomarkers indicating exposure, physiological impacts of e-cigarettes on tissues and organ systems, as well as data regarding e-cigarette users and their usage trends.[77] Furthermore, there is a call for more thorough examinations of the immediate and prolonged health consequences of vaping to ascertain the safety and effectiveness of these devices, particularly concerning smoking. Such endeavors are essential to effectively address the emerging challenges that e-cigarettes and vaping pose to clinical medicine and public health.[77,84]

Conclusion

E-cigarettes, though marketed as safer alternatives to traditional tobacco, pose potential risks to oral health, including periodontal disease. Nicotine impairs healing and promotes inflammation, while aerosol emissions may further damage oral tissues. While some studies suggest benefits in smoking cessation, others indicate increased periodontal risks, necessitating further research. Dental practitioners should educate patients on vaping-related risks, and policymakers must enforce stricter regulations on marketing, product design, and chemical composition to safeguard public health.

Author's contribution

All authors have made substantial contributions to all of the following: (1) & (2) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships

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References

1. Reasoner JJ, Regier BA, Beckendorf R, McAllister RK. Update on the Risks of Electronic Cigarettes-Vaping. Ochsner J. 2020;20(1):2-4.
2. Baldassarri SR. Electronic Cigarettes: Past, Present, and Future: What Clinicians Need to Know. Clin Chest Med. 2020;41(4):797-807.
3. Mascarelli AL. Explainer: What are e-cigarettes? Science News Explores. https://www.snexplores.org/article/explainer-what-are-e-cigarettes. Published August 21, 2022
4. Anderson J, Anderson J. The Origins and Evolution of Vaping: From Early Patents to Today's E-Cigarettes. DOSvape. Published August 14, 2023. https://dosvape.com/guides/incremental-evolution-vaping/
5. Irusa KF, Vence B, Donovan T. Potential oral health effects of e-cigarettes and vaping: A review and case reports. Journal of Esthetic and Restorative Dentistry. 2020;32(3):260-264.
6. Holliday R, Chaffee BW, Jakubovics NS, Kist R, Preshaw PM. Electronic cigarettes and oral health. Journal of Dental Research. 2021;100(9):906-913.
7. Figueredo CA, Abdelhay N, Figueredo CM, Catunda R, Gibson MP. The impact of vaping on periodontitis: A systematic review. Clinical and Experimental Dental Research. 2020;7(3):376-384.
8. Johannsen A, Susin C, Gustafsson A. Smoking and inflammation: evidence for a synergistic role in chronic disease. Periodontology 2000. 2013;64(1):111-126.
9. Vaping Devices (Electronic Cigarettes) DrugFacts | National Institute on Drug Abuse. National Institute on Drug Abuse. Published February 14, 2025. https://nida.nih.gov/publications/drugfacts/vaping-devices-electronic-cigarettes
10. National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Board on Population Health and Public Health Practice; Eaton DL, Kwan LY, Stratton K, et al., eds. Public Health Consequences of E-Cigarettes. Washington (DC): National Academies Press (US); January 23, 2018.
11. Gupta V, Sharma M, Srikant N, Manaktala N. Assessment of knowledge of use of electronic cigarette and its harmful effects among young adults. Open Medicine. 2020;15(1):796-804.
12. Marques P, Piqueras L, Sanz MJ. An updated overview of e-cigarette impact on human health. Respir Res. 2021;22(1):151.
13. Javed F, Kellesarian S, Sundar I, Romanos G, Rahman I. Recent updates on electronic cigarette aerosol and inhaled nicotine effects on periodontal and pulmonary tissues. Oral Diseases. 2017;23(8):1052-1057.
14. Lallier TE, Moylan JT, Maturin E. Greater sensitivity of oral fibroblasts to smoked versus smokeless tobacco. Journal of Periodontology. 2017;88(12):1356-1365.
15. Corriden R, Moshensky A, Bojanowski CM, et al. E-cigarette use increases susceptibility to bacterial infection by impairment of human neutrophil chemotaxis, phagocytosis, and NET formation. AJP Cell Physiology. 2019;318(1):C205-C214.
16. Sayed IM, Masso-Silva JA, Mittal A, et al. Inflammatory phenotype modulation in the respiratory tract and systemic circulation of e-cigarette users: a pilot study. AJP Lung Cellular and Molecular Physiology. 2021;321(6):L1134-L1146.
17. Ganapathy V, Jaganathan R, Chinnaiyan M, et al. E-Cigarette Effects on Oral Health: A Molecular perspective. Food and Chemical Toxicology. Published online December 1, 2024:115216.
18. Xu F, Pushalkar S, Lin Z, et al. Electronic cigarette use enriches periodontal pathogens. Molecular Oral Microbiology. 2022;37(2):63-76.
19. Clapp PW, Pawlak EA, Lackey JT, et al. Flavored e-cigarette liquids and cinnamaldehyde impair respiratory innate immune cell function. AJP Lung Cellular and Molecular Physiology. 2017;313(2):L278-L292.
20. DiSilvio B, Baqdunes M, Alhajhusain A, Cheema T. Smoking addiction and strategies for cessation. Critical Care Nursing Quarterly. 2020;44(1):33-48.
21. Weera MM, Fields MA, Tapp DN, Grahame NJ, Chester JA. Effects of nicotine on alcohol drinking in female mice selectively bred for high or low alcohol preference. Alcoholism Clinical and Experimental Research. 2017;42(2):432-443.
22. Allegrini AG, Verweij KJH, Abdellaoui A, et al. Genetic vulnerability for smoking and cannabis use: associations with E-Cigarette and water pipe use. Nicotine & Tobacco Research. 2018;21(6):723-730.
23. Song MA, Mori KM, McElroy JP, et al. Accelerated epigenetic age, inflammation, and gene expression in lung: comparisons of smokers and vapers with non-smokers. Clinical Epigenetics. 2023;15(1):160
24. Caliri AW, Caceres A, Tommasi S, Besaratinia A. Hypomethylation of LINE-1 repeat elements and global loss of DNA hydroxymethylation in vapers and smokers. Epigenetics. 2020;15(8):816-829.
25. Hamad SH, Brinkman MC, Tsai YH, et al. Pilot Study to Detect Genes Involved in DNA Damage and Cancer in Humans: Potential Biomarkers of Exposure to E-Cigarette Aerosols. Genes (Basel). 2021;12(3):448.
26. Tommasi S, Pabustan N, Li M, Chen Y, Siegmund KD, Besaratinia A. A novel role for vaping in mitochondrial gene dysregulation and inflammation fundamental to disease development. Sci Rep. 2021;11(1):22773.
27. Torabi S, Soni A. Histology, Periodontium. In: StatPearls. Treasure Island (FL): StatPearls Publishing; March 27, 2023.
28. Gasner NS, Schure RS. Periodontal Disease. In: StatPearls. Treasure Island (FL): StatPearls Publishing; April 10, 2023.
29. Van Dyke TE, Sheilesh D. Risk factors for periodontitis. J Int Acad Periodontol. 2005;7(1):3-7.
30. Charde P, Ali K, Hamdan N. Effects of e-cigarette smoking on periodontal health: A scoping review. PLOS Glob Public Health. 2024;4(3):e0002311.
31. Malhotra R, Kapoor A, Grover V, Kaushal S. Nicotine and periodontal tissues. J Indian Soc Periodontol. 2010;14(1):72-79. doi:10.4103/0972-124X.65442
32. Romanenko IG, Gorobets IV, Gorobets SM, Bobkova SA, Jerelei AA, Gorobets OV. The effect of electronic cigarettes on the oral microbiome and antibacterial properties of saliva. Medical News of the North Caucasus. 2023;18(4).
33. Karaaslan F, Dikilitaş A, Yiğit U. The effects of vaping electronic cigarettes on periodontitis. Aust Dent J. 2020;65(2):143-149.

34. Adhi YI, Pribadi IMS, Amaliya A. Gingival Inflammatory Response in Tobacco Smokers Compared to Vapers: A Scoping Review. J Int Dent Med Res 2022; 15(4): 1763-1768.
35. Ye D, Rahman I. Emerging Oral Nicotine Products and Periodontal Diseases. Int J Dent. 2023;2023:9437475.
36. Javed F, Kellesarian SV, Sundar IK, Romanos GE, Rahman I. Recent updates on electronic cigarette aerosol and inhaled nicotine effects on periodontal and pulmonary tissues. Oral Dis. 2017;23(8):1052-1057.
37. Isik Andrikopoulos G, Farsalinos K, Poulas K. Electronic Nicotine Delivery Systems (ENDS) and Their Relevance in Oral Health. Toxics. 2019;7(4):61.
38. Iacob AM, Escobedo Martínez MF, Barbeito Castro E, Junquera Olay S, Olay García S, Junquera Gutiérrez LM. Effects of Vape Use on Oral Health: A Review of the Literature. Medicina (Kaunas). 2024;60(3):365.
39. Thiem DGE, Donkiewicz P, Rejaey R, et al. The impact of electronic and conventional cigarettes on periodontal health-a systematic review and meta-analysis. Clin Oral Investig. 2023;27(9):4911-4928.
40. Jeong W, Choi DW, Kim YK, et al. Associations of electronic and conventional cigarette use with periodontal disease in South Korean adults. J Periodontol. 2020;91(1):55-64.
41. Xu F, Aboseria E, Janal MN, et al. Comparative Effects of E-Cigarette Aerosol on Periodontium of Periodontitis Patients. Front Oral Health. 2021;2:729144.
42. Tatullo M, Gentile S, Paduano F, Santacroce L, Marrelli M. Crosstalk between oral and general health status in e-smokers. Medicine (Baltimore). 2016;95(49):e5589.
43. Javed F, Abduljabbar T, Vohra F, Malmstrom H, Rahman I, Romanos GE. Comparison of Periodontal Parameters and Self-Perceived Oral Symptoms Among Cigarette Smokers, Individuals Vaping Electronic Cigarettes, and Never-Smokers. J Periodontol. 2017;88(10):1059-1065.
44. Irusa KF, Finkelman M, Magnuson B, Donovan T, Eisen SE. A comparison of the caries risk between patients who use vapes or electronic cigarettes and those who do not: A cross-sectional study. J Am Dent Assoc. 2022;153(12):1179-1183.
45. Altabatabaie A, Alquzweeni A, Alnajar H, Dalol R. E-Cigarette vaping and Periodontium: A Systematic review. Indian Journal of Forensic Medicine & Toxicology. Published online January 7, 2021. doi:10.37506/ijfmt.v15i1.13516
46. Charde P, Ali K, Hamdan N. Effects of e-cigarette smoking on periodontal health: A scoping review. PLOS Glob Public Health. 2024;4(3):e0002311
47. D'Ambrosio F, Pisano M, Amato A, Iandolo A, Caggiano M, Martina S. Periodontal and Peri-Implant Health Status in Traditional vs. Heat-Not-Burn Tobacco and Electronic Cigarettes Smokers: A Systematic Review. Dent J (Basel). 2022;10(6):103.
48. Ibraheem W, Bokhari AM, Alam MN, Munthiri HA, Arishi HA, Alsabei AK. Relationship of Periodontal Disease and Electronic Cigarette Usage among Adolescents in Jazan Population, KSA. Journal of International Dental and Medical Research. 2024;17(1):346-351.
49. Alkattan R, Tashkandi N, Mirdad A, Ali HT, Alshibani N, Allam E. Effects of Electronic Cigarettes on Periodontal Health: A Systematic Review and Meta-Analysis. International Dental Journal. Published online January 1, 2025. doi:10.1016/j.identj.2024.12.036
50. Thiem DGE, Donkiewicz P, Rejaey R, et al. The impact of electronic and conventional cigarettes on periodontal health-a systematic review and meta-analysis. Clin Oral Investig. 2023;27(9):4911-4928.
51. Cichońska D, Kusiak A, Goniewicz ML. The Impact of E-Cigarettes on Oral Health-A Narrative Review. Dent J (Basel). 2024;12(12):404.
52. Isik Andrikopoulos G, Farsalinos K, Poulas K. Electronic Nicotine Delivery Systems (ENDS) and Their Relevance in Oral Health. Toxics. 2019;7(4):61.
53. Alqahtani S, Cooper B, Spears CA, Wright C, Shannahan J. Electronic nicotine delivery system-induced alterations in oral health via saliva assessment. Exp Biol Med (Maywood). 2020;245(15):1319-1325.
54. Karaaslan F, Dikilitaş A, Yiğit U. The effects of vaping electronic cigarettes on periodontitis. Aust Dent J. 2020;65(2):143-149.
55. Rom O, Pecorelli A, Valacchi G, Reznick AZ. Are E-cigarettes a safe and good alternative to cigarette smoking? Ann N Y Acad Sci. 2015;1340:65-74.
56. Abbott AJ, Reibel YG, Arnett MC, Marka N, Drake MA. Oral and Systemic Health Implications of Electronic Cigarette Usage as Compared to Conventional Tobacco Cigarettes: A review of the literature. J Dent Hyg. 2023;97(4):21-35.
57. Kennedy RD, Awopegba A, De León E, Cohen JE. Global approaches to regulating electronic cigarettes. Tob Control. 2017;26(4):440-445. doi:10.1136/tobaccocontrol-2016-053179
58. Lee CM. International regulatory overview of electronic cigarettes and heated tobacco products. Journal of Korean Medical Association. 2020;63(2):112.
59. Wasowicz A, Feleszko W, Goniewicz ML. E-Cigarette use among children and young people: the need for regulation. Expert Rev Respir Med. 2015;9(5):507-509.
60. Pudło A, Gruszczynski L. Regulating e-cigarettes at the EU level. In: Edward Elgar Publishing eBooks. 2019.
61. Rosenkilde Laursen K, Bønløkke JH, Bendstrup E, et al. An RCT of acute health effects in COPD-patients after passive vape exposure from e-cigarettes. Eur Clin Respir J. 2020;8(1):1861580.
62. Hess IM, Lachireddy K, Capon A. A systematic review of the health risks from passive exposure to electronic cigarette vapour. Public Health Res Pract. 2016;26(2):2621617.
63. Su WC, Lee J, Zhang K, Wong SW, Buu A. Estimation of Health Risks Caused by Metals Contained in E-Cigarette Aerosol through Passive Vaping. Toxics. 2023;11(8):684. doi:10.3390/toxics11080684
64. Su WC, Lin YH, Wong SW, Chen JY, Lee J, Buu A. Estimation of the dose of electronic cigarette chemicals deposited in human airways through passive vaping. J Expo Sci Environ Epidemiol. 2021;31(6):1008-1016.
65. Casanova-Cháfer J, Gallart-Mateu D, Armenta S, De La Guardia M. Preliminary results about the breath of passive smokers and vapers based on the use of portable air monitoring devices. Microchemical Journal. 2016;126:454-459.
66. Budney AJ, Sargent JD, Lee DC. Vaping cannabis (marijuana): parallel concerns to e-cigs?. Addiction. 2015;110(11):1699-1704.
67. Papaefstathiou E, Stylianou M, Agapiou A. Main and side stream effects of electronic cigarettes. J Environ Manage. 2019;238:10-17.
68. Logue JM, Sleiman M, Montesinos VN, et al. Emissions from Electronic Cigarettes: Assessing Vapers' Intake of Toxic Compounds, Secondhand Exposures, and the Associated Health Impacts. Environ Sci Technol. 2017;51(16):9271-9279.
69. Palmisani J, Di Gilio A, Palmieri L, et al. Evaluation of Second-Hand Exposure to Electronic Cigarette Vaping under a Real Scenario: Measurements of Ultrafine Particle Number Concentration and Size Distribution and Comparison with

Traditional Tobacco Smoke. Toxics. 2019;7(4):59. Published 2019 Nov 25.
70. Li L, Zhu Y. Vaping and Secondhand Exposure. Handbook of Indoor Air Quality, 2022. https://doi.org/10.1007/978-981-16-7680-2_7.
71. Hasan NWM, Baharin B, Mohd N. Electronic Cigarette vapour and the Impacts on oral Health: a review. Archives of Orofacial Sciences. 2022;17(Supp. 1):1-9.
72. Son Y, Weisel C, Wackowski O, Schwander S, Delnevo C, Meng Q. The Impact of Device Settings, Use Patterns, and Flavorings on Carbonyl Emissions from Electronic Cigarettes. International Journal of Environmental Research and Public Health. 2020;17(16):5650.
73. Ruth T, Daniel J, König A, Trittler R, Garcia-Käufer M. Inhalation toxicity of thermal transformation products formed from e-cigarette vehicle liquid using an in vitro lung model exposed at the Air–Liquid Interface. Food and Chemical Toxicology. 2023;182:114157.
74. Figueredo CA, Abdelhay N, Figueredo CM, Catunda R, Gibson MP. The impact of vaping on periodontitis: A systematic review. Clin Exp Dent Res. 2021;7(3):376-384.
75. Geiss O, Bianchi I, Barahona F, Barrero-Moreno J. Characterisation of mainstream and passive vapours emitted by selected electronic cigarettes. Int J Hyg Environ Health. 2015;218(1):169-180. doi:10.1016/j.ijheh.2014.10.001
76. Wu D, O'Shea DF. Potential for release of pulmonary toxic ketene from vaping pyrolysis of vitamin E acetate. Proc Natl Acad Sci U S A. 2020;117(12):6349-6355.
77. Walton KM, Abrams DB, Bailey WC, et al. NIH electronic cigarette workshop: developing a research agenda. Nicotine Tob Res. 2015;17(2):259-269.
78. Correa JB, Ariel I, Menzie NS, Brandon TH. Documenting the emergence of electronic nicotine delivery systems as a disruptive technology in nicotine and tobacco science. Addictive Behaviors. 2016;65:179-184.
79. Harlow AF, Fetterman JL, Ross CS, et al. Association of device type, flavours and vaping behaviour with tobacco product transitions among adult electronic cigarette users in the USA. Tob Control. 2022;31(e1):e10-e17.
80. Bold K, O'Malley S, Krishnan-Sarin S, Morean M. E-cigarette Use Patterns, Flavors, and Device Characteristics Associated With Quitting Smoking Among a U.S. sample of Adults Using E-cigarettes in a Smoking Cessation Attempt. Nicotine Tob Res. 2023;25(5):954-961.
81. Brown CJ, Cheng JM. Electronic cigarettes: product characterisation and design considerations. Tob Control. 2014;23:ii4-ii10.
82. Ebajemito JK, McEwan M, Gale N, Camacho OM, Hardie G, Proctor CJ. A randomised controlled single-centre open-label pharmacokinetic study to examine various approaches of nicotine delivery using electronic cigarettes. Sci Rep. 2020;10(1):19980.
83. Cahours X, Prasad K. A review of Electronic cigarette use behaviour Studies. Beiträge Zur Tabakforschung International. 2018;28(2):81-92.
84. Palazzolo DL. Electronic cigarettes and vaping: a new challenge in clinical medicine and public health. A literature review. Front Public Health. 2013;1:56.