Implications of the use of the "vape" electronic cigarette on oral health – summary of current evidence

Implicações do uso do cigarro eletrônico "vape" na saúde bucal – síntese de evidências atuais

Implicaciones del uso del cigarrillo electrónico "vape" en la salud bucal – resumen de la evidencia actual

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RESUMO

Objetivo: Analisar e apontar as implicações do uso dos cigarros eletrônicos na saúde bucal por meio de uma revisão integrativa de literatura. **Método**: Revisão integrativa com busca de dados realizada nas bases, BVS, PubMed e Google Acadêmico, por estudos clínicos em inglês, português e espanhol, publicados entre 2013 e 2023 com dados relevantes sobre as implicações do uso do cigarro eletrônico na saúde bucal. Foram excluídos, os artigos que não respondiam à questão da pesquisa, duplicados, revisão de literatura e estudos com animais. **Resultados:** Os dezoito estudos incluídos nesta pesquisa demonstraram uma variedade de implicações bucais com efeitos periodontais, dentários, microbioma oral, citotóxicos e oncológicos. Sob esse viés, foi relatado que essas sintomatologias foram relativamente menores e temporárias para os fumantes convencionais que mudaram para cigarros eletrônicos. **Conclusões:** Os resultados desta revisão sugerem que uma ampla gama de implicações na saúde bucal pode estar associada ao uso de cigarros eletrônicos, pois contém substâncias tóxicas e não devem ser considerados inofensivos.
Descritores: Cigarros eletrônicos;. Implicações bucais. Saúde oral; Tabagismo.

ABSTRACT

Objective: To analyze and highlight the implications of the use of electronic cigarettes on oral health through an integrative literature review. Method: Integrative review with data search carried out in the databases, VHL, PubMed and Google Scholar, for clinical studies in English, Portuguese and Spanish, published between 2013 and 2023 with relevant data on the implications of electronic cigarette use on oral health. Articles that did not answer the research question, duplicates, literature reviews and animal studies were excluded. Results: The eighteen studies included in this research demonstrated a variety of oral implications with periodontal, dental, oral microbiome, cytotoxic and oncological effects. Under this bias, it was reported that these symptoms were relatively minor and temporary for conventional smokers who switched to electronic cigarettes. Conclusions: The results of this review suggest that a wide range of oral health implications may be associated with the use of electronic cigarettes, as they contain toxic substances and should not be considered harmless.
Descriptors: Electronic cigarettes; Oral implications; Oral health. Smoking.

RESUMEN

Objetivo: Analizar y resaltar las implicaciones del uso de cigarrillos electrónicos en la salud bucal a través de una revisión integrativa de la literatura. **Método:** Revisión integrativa con búsqueda de datos realizada en las bases de datos BVS, PubMed y Google Scholar, de estudios clínicos en inglés, portugués y español, publicados entre 2013 y 2023 con datos relevantes sobre las implicaciones del uso del cigarrillo electrónico en la salud bucal. Se excluyeron artículos que no respondieron a la pregunta de investigación, duplicados, revisiones de literatura y estudios en animales. **Resultados:** Los dieciocho estudios incluidos en esta investigación demostraron una variedad de implicaciones bucales con efectos periodontales, dentales, microbioma bucal, citotóxicos y oncológicos. Bajo este sesgo, se informó que estos síntomas eran relativamente menores y temporales para los fumadores convencionales que cambiaron a los cigarrillos electrónicos. **Conclusión:** Los resultados de esta revisión sugieren que una amplia gama de implicaciones para la salud bucal pueden estar asociadas con el uso de cigarrillos electrónicos, ya que contienen sustancias tóxicas y no deben considerarse inofensivos.
Descriptores: Cigarrillos electrónicos; Implicaciones orales; Salud bucal; De fumar.

REVIEW

Introduction

Smoking is considered the leading cause of preventable death and an important public health problem worldwide, and in Brazil, it is considered an epidemic disease.[1] Since its appearance in 2003, electronic cigarettes have achieved worldwide popularity, especially among young people and adults. These electronic nicotine delivery devices have emerged as an alternative to reduce the risks and harms of conventional cigarettes (CC) and as an option to aid in smoking cessation.[2]

The term "smoking" gave rise to the term "vaping", which consists of inhaling an aerosolized "e-liquid", produced by an electronic vaping device, which does not require combustion, an electronic nicotine delivery system (ENDS). Electronic cigarettes, also known as "e-cigs", "vapes" and "pods", among other names, are mechanical-electronic devices powered by a lithium battery that are predominantly made up of propylene glycol, glycerin, flavorings to impart flavor, as well as candy, fruits, menthol and tobacco, and may or may not contain nicotine.[3-4]

Thus, these components together, after thermal decomposition, primarily reach the mouth, contributing to the development and potentiation of diseases that affect the stomatognathic system, as well as xerostomia, nicotinic stomatitis, angular cheilitis, hyperplastic candidiasis, hairy tongue, increased bacterial plaque, increased periodontal pocket, bone loss, carious lesion, irritation of the oral mucosa, periodontal disease, Demineralization of tooth enamel and halitosis.[5]

The rampant use of VAPES in terms of oral health is also associated with oral diseases and local inflammation, oxidative stress and cellular changes, however, even though they are less harmful compared to conventional cigarettes, e-cigs release carcinogenic and cytotoxic agents.[6]

Although commercially e-cigarettes are promoted as a safer alternative to traditional cigarettes, long-term epidemiological data to support this claim is lacking. Evidence on the effects on oral health in clinical trials remains limited, with most studies to date being small-scale and often cross-sectional in design, making more randomized controlled trials necessary for more evidence on this trend that is now a public health concern.[7]

In view of the relevance of this very current theme in the social, epidemiological and clinical fields, the present study, through an integrative literature review, aims to analyze and point out the implications of the use of electronic cigarettes on oral health.

Method

The present study was an integrative literature review that consisted of analyzing the relationship between the use of electronic cigarettes and oral manifestations. During the construction of this review, the following methodological steps were followed: Identification of the theme and elaboration of the guiding question; Delimitation of inclusion and exclusion criteria for the selection of articles; Identification of pre-selected and selected studies, Categorization of selected studies; Analysis and interpretation of

results; finally, Presentation of the synthesis of knowledge.

For the present review, the guiding question was elaborated by the PICO strategy, namely: P (patient/population): smokers; I (intervention) Smoking e-cigarettes; C(control): does not apply; The (result) changes in oral biological tissues. Thus, the guiding question was: What are the oral implications caused by the use of electronic cigarettes?.

Based on the guiding perspective, a survey of articles was carried out for the integrative review, in the period from February to August 2023, through three databases, such as: National Library of Medicine National Institutes of Health (PubMed), Virtual Health Library (VHL) and Google Scholar.

The search for studies relied on the indexers present in the Health Sciences Descriptors (DECS) and in the Medical Subject Headings (MESH) of the Virtual Health Library. Thus, the descriptors used for the search were: electronic cigarettes, electronic smoking devices, oral lesions, oral manifestations, oral cavity, nicotine vaporization, dentistry, stomatological manifestations in two search strategies. In addition, the interaction of these descriptors was performed by the Boolean operators AND and OR, namely: "oral manifestations and electronic cigarettes", "oral cavity and electronic cigarettes", "periodontitis and electronic cigarettes", "oral lesions and electronic cigarettes", "oral health and electronic cigarettes".

Chart 1- Combination of the descriptors used in the systematic search and resulting articles.

1ª strategy – PubMed and VHL	(Stomatognathic Diseases [MeSH]) AND (Electronic Nicotine DeliverySystems [MeSH]) OR (oral health [MeSH Terms]) OR oral medicine ([MeSH Terms]) OR oral pathology ([MeSH Terms]) OR mouth diseases [MeSH Terms]) OR melanosis [MeSH Terms] OR melanosis OR periodontal diseases [MeSH Terms] OR "oral health") OR "oral lesions") OR "oral cancer" OR "mucosal lesions") OR tongue) OR cheilitis) OR stomatitis) OR candidiasis) OR leukoplakia) OR periodont* OR gingiv*) OR teeth) OR dental) AND (((((Electronic Nicotine Delivery Systems [MeSH Terms]) OR e-cig*) OR e-smoker*) OR e-cigarette*) OR"electronic cigarette*"))))))))
2ª strategy – Google Scholar	Cavidade oral AND cigarros eletrônicos.

The initial selection of the articles to be included was carried out by two authors blindly and independently, and the third evaluator critically reviewed the selection in the study. In addition, for each study, descriptive and quantitative information was collected in a spreadsheet constructed by the investigators, containing data regarding the identification of the article as well as title, year, study design, objective, authors, and place of search.

The details and results of the stages of the integrative review are organized in Chart 2.

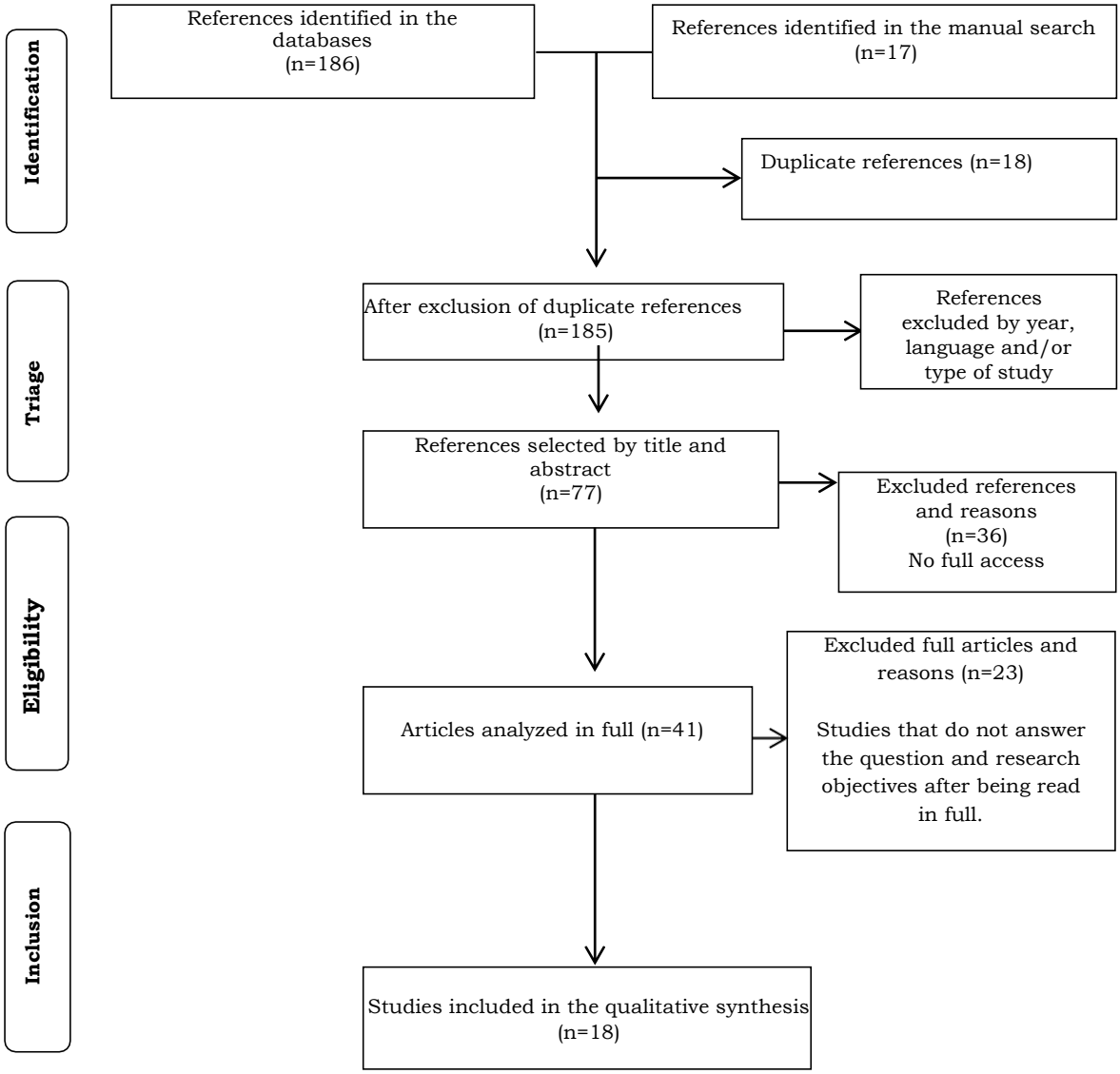
Chart 2 – Details of the stages of the integrative review with results obtained**.**

Step	Detailing	Results
1ª	Theme	Implications of the use of electronic cigarettes "vape" on oral health
	Guiding question	What are the oral implications caused by the use of of the electronic cigarette?
	Goal	Conduct an integrative review of the literature on the oral implications caused by the use of electronic cigarettes.
	Search strategy	1. Detailed in Table I. 2. Oral cavity and eletronic cigarettes
	Descriptors in DECS/MESH	Electronic cigarettes. Oral cavity. Oral health. (DECS) Eletronic cigarettes. Oral cavity. Oral health. (MESH)
	Virtual Library	1. Virtual Health Library (VHL) 2. PubMed 3. Google Scholar
2ª	Data Collection Period	February to August 2023
	Inclusion criteria	1. Articles with a correlation with oral health 2. Relevant data on the effects of e-cigarettes on the oral cavity 3. Full text available 4. Language in English, Portuguese and Spanish 5. Published in the last 10 years
	Exclusion Criteria	1. Duplicate article 2. Literature review 3. Articles that did not answer the research question 4. Articles related to other areas of health 5. Animal studies
3ª	Number of selected works	18
4ª	Study design with the analysis of the scientific works investigated	Randomized controlled clinical trial In vivo study Cohort Systematic review of the literature
5ª	Analysis, interpretation and discussion of results	The results of this step are present in the Sections: Results and discussion of the present work

Results

Figure 1 shows a flowchart of the selection process of the included studies and the results of the search strategy of the present review. The main information of the publications included is organized in Chart 3.

Figure 1 – Flowchart of the results of the search strategy and selection of studies according to the PRISMA recommendation.



Source: Own authorship (2023)

Chart 3. Summary of published articles on oral manifestations with the use of electronic cigarettes (continues)

Author/Year	Objective	Results	Conclusion
El-Sakhawy et al., 2023[8]	To investigate the oral association as one of the etiologic agents of prosthetic stomatitis in electronic smokers.	Smoking has been shown to affect oral health such as (abnormality in the oral mucosa, mouth ulcers, bad breath, and dry and candida mouth feeling).	The study concluded that smoking was a significant positive correlation with the presence of Candida in the oral cavity.
Thiem etal., 2023[9]	This systematic review and meta-analysis aimed to examine the effects of e-cigarettes on periodontal health compared to conventional cigarette smoke and a non-smoking population.	E-cigarette smokers were found to have a lower plaque index, probing depth, attachment loss, and marginal bone loss compared to conventional cigarette smokers.	It was concluded that the use of electronic cigarettes can be considered a healthier alternative to smoking with regard to periodontal health. Even so, harmful effects on periodontal health have also been observed.
Catala-Valentin et al., 2022[10]	To evaluate the consequences of e-cig aerosol exposure on selected commensal and pathogenic species.	The aerosols of e-cigs disrupt oral bacterial homeostasis, suppressing the growth of commensals and increasing the biofilm formation of the pathogen S. mutans.	Exposure to the e-cigarette aerosol prevents the growth of two streptococcal commensals and increases biofilm formation, hydrophobicity, and binding to the pathogen S. mutans.
Cichonska et al., 2022[11]	Pilot investigation to observe if there has been any change in the oral bacteria of e-cigarette users.	The co-occurrence of commensal and pathogenic bacteria from oral cavity vapers was higher than in traditional cigarette smokers.	The use of e-cigs caused changes in pathogenic oral bacteria compared to traditional cigarette smokers and non-smokers.
Thomas et al., 2022[12]	Longitudinal study to analyze the adverse effects of e-cigarette use on periodontal health.	The microbiome of vapes in which it maintained a unique subgingival microbial community, enriched in Fusobacterium and Bacteroidales.	E-cigs promote a unique periodontal microbiome, a stable heterogeneous state presenting unique oral health challenges.
Xu et al., 2022[7]	To explore the effects of E-liquids and flavors on the formation and growth of biofilms and to investigate the mechanism of inhibition.	Flavoring agents have a bactericidal mode of inhibition of the growth of these oral streptococci.	The study showed that flavored E-liquids are more harmful to the formation of biofilm and the growth of oral commensal bacteria.
Wasfi et al., 2022[13]	The aim was to update the chronic health outcomes associated with e-cigarette use.	Periodontal buccal sapude has shown a worse diagnosis of gum disease, bone loss, or vapers' periodontal disease.	Vapers showed worse periodontal parameters in daily users than in non-smokers.
Figueredo et al., 2021[14]	Systematically review the literature on the impact of vaping on periodontitis.	It showed plaque enlargement, marginal bone loss, pocket depth, and reduced bleeding on probing in e-cig users.	The available results point to an increase in the destruction of the periodontium leading to the development of periodontitis.

Chart 3. Summary of published articles on oral manifestations with the use of electronic cigarettes (conclusion)

Author/Year	Objective	Results	Conclusion
Rouabhia et al., 2020[15]	To evaluate the effect of e-cigs on S. mutans growth, biofilm, and virulence gene expression.	Increase in growth of S. mutans with e-cigs and increase in biofilm mass after six exposures to nicotine e-cigs.	The e-cigs increased the growth of S. mutans and the expression of virulent genes. The e-cigs promotes the outside surfaces of the teeth.
Yang et al., 2020[16]	Systematically review the available research evidence on the impact of e-cigarette use on oral health.	Mouth effects, throat, periodontal, dental, cytotoxic, genotoxic, and oncological effects, effects on the oral microbiome, and traumatic injuries.	While switching to e-cigs may mitigate symptomatology in conventional smokers, use has shown a range of oral health sequelae.
Alanazi et al., 2019[17]	To evaluate the impact of e-cigs on the growth of C. albicans that may increase the risk of oral thrush.	An increase in the growth of C. albicans, high levels of chitin, was observed. In contact with gingival epithelial cells.	E-cigarettes may interact with C. albicans to promote its pathogenesis, which may increase the risk of oral thrush.
Flach et al., 2019[18]	To systematically evaluate the association between e-cigse and head and neck cancer, on the carcinogenic effects of e-cigs.	Some reports have suggested DNA damage following exposure to e-cigs due to increased oxidative stress.	Our review describes the potential dangers associated with the use of e-cigarettes and their role in NH cancers.
Hollyday et al., 2019[19]	Systematic review to evaluate the in vitro effects of nicotine on human gingiva, periodontal ligament and epithelial cells.	Effects can be seen across a range of nicotine concentrations, but results have often been contradictory.	There was limited and contradictory evidence of the effects of nicotine on air fixation, proliferation, and production of inflammatory mediators.
Ralho et al., 2019[4]	This systematic review aims to evaluate the adverse effects of e-cigs on oral health.	Nicotine stomatitis, hairy tongue and angular chelitis in e-cigs consumers.	E-cigarettes are less harmful than conventional cigarettes.
Tommasi et al., 2019[6]	This is a case-control study to investigate the regulation of genes and molecular pathways in oral cells of e-cig users and conventional smokers.	The analyses revealed that "cancer" was the main disease associated with dysregulated genes.	It was concluded that dysregulation of important genes and associated molecular pathways in the oral epithelium of vapers.
Kim et al., 2018[20]	An in vitro study investigated changes in cariogenic potential on tooth surfaces exposed to e-cigs aerosols.	Exposure to flavored aerosols led to an increase in biofilm formation and a decrease in enamel hardness.	Aerosols have high sucrose content, gelatinous and acidic beverages that can increase the risk of cariogenic potential.
Bardellini et al., 2017[21]	Case-control to evaluate the characteristics of oral mucosal lesions (LMO).	Nicotine stomatitis, hairy tongue and angular cheilitis were found to be more common.	Increasing prevalence of three specific types of OML among EC consumers.
Sundar etal., 2016[22]	An in vitro study evaluated the relationship between the use of e-cigs with flavoring substances and their relationship with inflammatory responses.	E-cigs with flavorings increase oxidative stress and release inflammatory cytokines in human periodontal ligament fibroblasts.	It was concluded that increased oxidative stress, pro-inflammatory responses may result in dysregulated repair in periodontal cells.

Discussion

The use of electronic cigarettes has been popularized in recent years, becoming a trend for young people and adults, being highly addictive due to the substances present, especially nicotine. The harms of this practice are widely known by recent studies that demonstrate the implication of the use of electronic cigarettes in the oral cavity.[16]

In the first analysis, it can be inferred that of the 18 studies, 5 addressed periodontal health[14,9,12,13,16], raising the notion that the use of electronic cigarettes promotes a unique periodontal microbiome. Therefore, e-cig users had a lower plaque index, probing depth, attachment loss, and marginal bone loss compared to conventional cigarette smokers, but with worse periodontal health than nonsmokers, leading to the development of periodontitis.

The oral microbiome is dominated by oral commensal Streptococcus spp. E-cig aerosols have the potential to disrupt oral bacterial homeostasis by suppressing the growth of commensals while increasing biofilm formation of the opportunistic pathogen S. mutans. As a result, e-cigarettes have been found to cause dysbiosis by affecting the growth of oral commensals, allowing the growth of opportunistic pathogens.[10]

The microbiome of vapers exists as an intermediate state between that of the conventional smoker and that of the non-smoker with more similarities to the status of the conventional smoker12,7 On the other hand, other authors have reported that vaping users have results closer to those of non-smokers than conventional cigarette smokers.[14]

Thus, the aerosols have physicochemical properties similar to those of high-sucrose sweets, gelatinous and acidic beverages that, in addition to increasing the risk of cariogenic potential, the flavored aerosols increased the formation of biofilm and there was a decrease in enamel hardness compared to unflavored controls.[20]

Among the variety of flavors of e-cigarettes, increased menthol concentrations have been shown to be more likely to cause oral mucosal irritation than increased nicotine concentrations. In addition, they showed symptoms with effects on the mouth, throat, dental, cytotoxic and effects on the oral microbiome.[9,16]. In this sense, studies have shown that flavored e-liquids are more harmful to the formation of biofilm and the growth of oral commensal bacteria.[7,10,15]

During the vaporization of these devices, a heat wave is generated that can cause lesions in the oral mucosa. Nine different lesions were detected, with nicotine stomatitis, hairy tongue and angular cheilitis being more prevalent among EC consumers, with no significant differences among former smokers.[4,21]

Exposure of oral epithelial cells to e-cigarette vapor causes dysregulation of critically important genes, increases oxidative stress, and release of inflammatory cytokines in periodontal ligament fibroblasts. As a result, studies have shown DNA damage, which has increased carcinogenic effects and increased the risk of head and neck cancer.[6,18,19,22]

As a result of the morphological and cellular alteration, studies concluded that there was a significant positive correlation between e-cigarettes and hyperplastic candidiasis, caused by the increase in the growth of Candida albicans, as one of the etiologic agents of prosthetic stomatitis in e-smokers.[8,17] On the other hand, according to Cichonska et al.[11], there were no statistically significant differences in the presence of Candida albicans. However, it revealed a more frequent colonization of the oral cavity by Candida spp. among e-cigarette users and traditional smokers compared to non-smokers.

While switching to e-cigarettes may mitigate oral symptomatology in conventional smokers, use has shown a wide range of oral health sequelae.[16]

Conclusion

The use of e-cigarettes may be associated with lesions of the oral mucosa, changes in the oral microbiome, dental, and periodontal damage and that e-liquids have cytotoxic properties. Thus, we highlight the need to continue developing more and more randomized controlled clinical studies that show these long-term consequences.

In addition, there is a need for orientation campaigns and warnings in the media about the risks of this product, and better training of health professionals to educate patients about the effects of e-cigarette use. It is the responsibility of the dentist to provide guidance on care and prevention in relation to the harm that electronic cigarettes represent to the individual's oral and systemic health, which can be aggravated by frequent consumption.

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