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Effects of E-cigarette on Oral Health – A Systematic Scoping Review

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Abstract:

Background: E-cigarettes have been perceived as a safer product compared to conventional cigarettes and have often been used for the purpose of cigarette smoking cessation. The aim of this scoping review is to provide a systematic review of the existing literature on the effects of e-cigarettes on human oral health and oral tissues. **Methodology:** Systematic literature search was undertaken and reviewed independently by two experts in online databases till May 2019. Both human and in-vitro studies were included. Guidelines of preferred reporting items for systematic reviews and meta-analyses for scoping reviews (PRISMA-ScR) were followed for reporting of the data. **Results:** A total of 24 studies were included following removal of duplicates, title and abstract screening and; full text screening. E-cigarettes have deleterious effects on the oral cavity tissues comprising of clinical findings of periodontium, gingiva, oral hygiene and micro-organism growth. In addition, there is a threat of serious injuries associated with e-cigarette explosion. In-vitro studies reveal e-cigarette use may lead to oxidative damage, altered morphology, reduced cell viability and cytotoxicity of oral epithelial and fibroblast cells. **Conclusions:** Though e-cigarettes have been found to be less harmful than the conventional cigarette smoking, there is a need to exercise caution while considering it as a smoking cessation tool. Longitudinal population-based studies are required for analyzing its *in-vivo* effect on oral tissues.

Keywords: E-Cigarette, Electronic Nicotine Delivery Systems, Oral Health, Oral Mucosal Lesions, Periodontium, Scoping Review

1. Introduction

Electronic cigarettes (e-cigarettes) are battery-powered devices that provide nicotine and other additives to the user in the form of an aerosol[1]. They are commonly known as "e-cigs," "vapes," "e-hookahs," "vape pens," and "Electronic Nicotine Delivery Systems (ENDS)". They may resemble regular cigarettes, cigars and pipes or; may look like USB flash drives, pens and other everyday items[2]. These devices were introduced in 2004, marketed as healthy alternative to tobacco. Since then, the e-cigarette industry has evolved on a global scale with World Health Organization (WHO) reporting an estimated worth of $3 billion with 500 brands and 8000 flavors[3].

The United States National Youth Tobacco Survey (NYTS) reported that e-cigarette use among middle and high school students increased alarmingly between 2017 and 2018, with over 3.6 million kids using e-cigarettes

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in 2018[4]. The Global Adult Tobacco Survey-2 India, 2016-17 reported that 0.02% of Indian adults were using e-cigarettes, sale of e-cigarettes had been banned in five Indian states (Jammu and Kashmir, Karnataka, Punjab, Maharashtra and Kerala) and that awareness of e-cigarettes was highest in the state of Delhi (13.3%), followed by Goa (10%)[3].

Few investigators indicates that e-cigarettes are less dangerous than cigarettes and hence have been investigated as tools for achieving long term smoking abstinence[5–7]. However, e-cigarette aerosols contain propylene glycol, glycerol, flavorings, other chemicals and nicotine which may produce mouth and throat irritation and dry cough[8]. The use of e-cigarettes continues to attain popularity as an alternative to cigarette smoking amongst young adults - as evidenced by a recent Indian survey of eight metropolitan cities wherein majority of the participants initiated use of e-cigarettes in lieu of cigarette

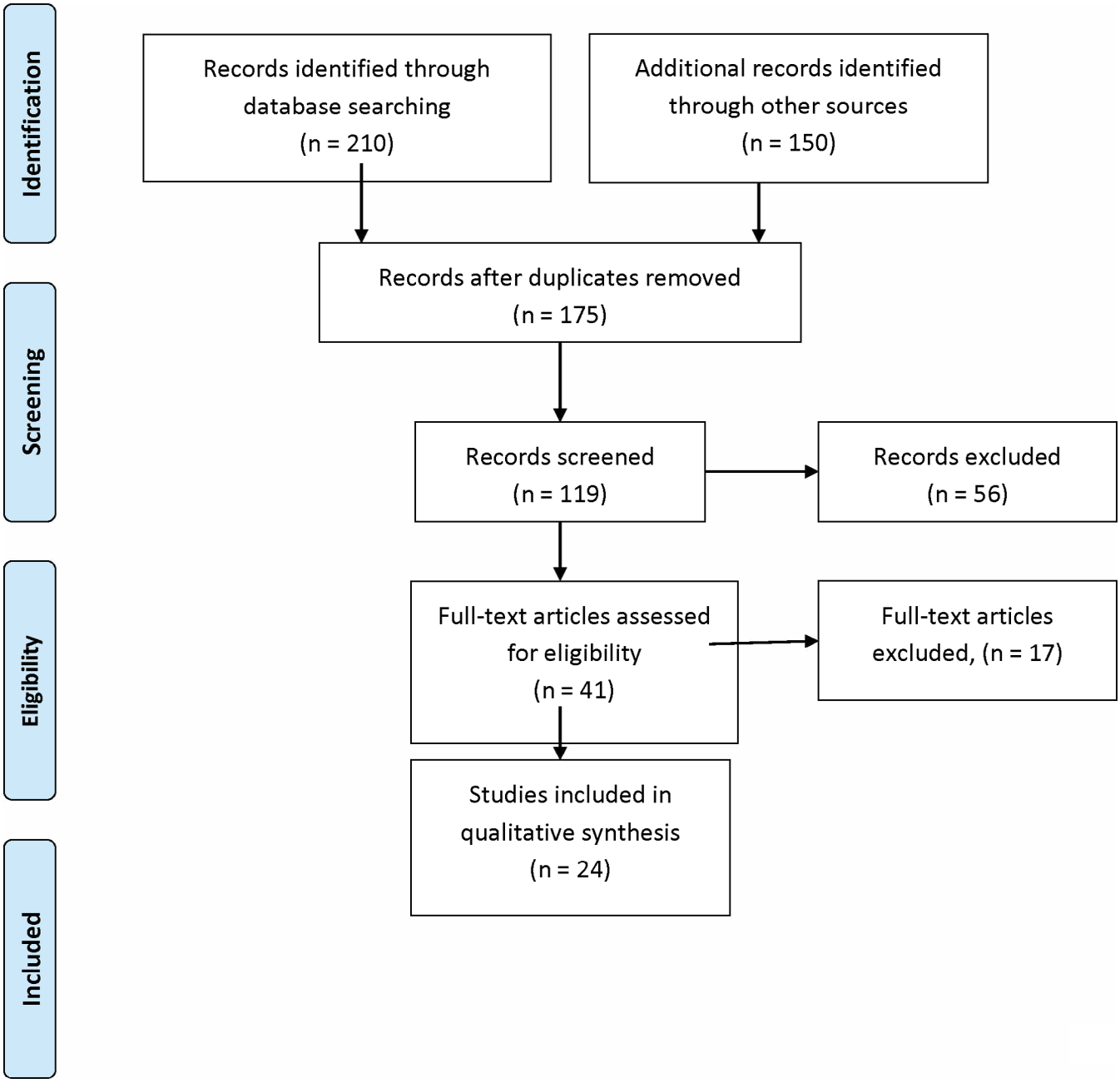


Figure 1. Outline of search strategy followed for the present systematic review according to PRISMA guidelines.

smoking for the purpose of smoking cessation[9]. Hence, the aim of this study was to systematically and critically review the existing literature on the effects of e-cigarettes on human oral health and oral tissues.

2. Methodology

This study has been reported in accordance with preferred reporting items for systematic reviews and meta-analyses for Scoping reviews (PRISMA-ScR) guidelines[10]. A Boolean literature search was undertaken on the primary databases: PubMed/MEDLINE and Google Scholar using the following keywords: 'E-cigarette', 'Electronic cigarette' or 'Electronic Nicotine Delivery System' and 'Oralpotentially malignant disorder', 'Gingiva', 'Gum', 'Periodontium', 'Oral Health', Oral Mucosa or 'Oral cancer'. The search strategy for Pubmed/MEDLINE was: (E-cigarette OR Electronic cigarette OR Electronic Nicotine Delivery System) and (Oral potentially malignant disorder OR Gingiva OR Gum OR Periodontium OR Oral Health OR Oral Mucosa OR Oral cancer). The search was conducted independently by two subject experts who performed initial 'title and abstract screening' followed by full text screening and data extraction of the selected publications. In the event of disagreement, discussions were held to reach a consensus regarding the suitability of the publication. All articles published till May 2019 in English language or other languages with summary providing detailed results in English were included with exposure variables being "Electronic Nicotine Delivery System (ENDS)" and "E-Cigarette". Studies including both smokers as well as E-cigarette users were considered only if separate results for E-cigarette users were provided. Outcome variables were oral health related outcomes. Study designs considered for review were: in vitro studies, animal experiments, case reports, case-control, cohort, cross-sectional studies and randomized controlled trials. Letters to the editor and reviews were excluded. The studies published by the tobacco company were also excluded. In addition, cross-references of all selected publications as well as earlier reviews on this topic were checked for more articles was performed by two blinded reviewers in accordance with the above-mentioned inclusion and exclusion criteria. Data extraction done by two independent reviewers was recorded in MS Excel sheet for: country of origin, sample size, methodology and outcome of the selected studies. Measures of effect considered were average mean, weighted mean, Odds ratio, relative risk ratio and absolute risk reduction.

3. Results

An initial search yielded 360 articles. Following removal of duplicates; title and abstract screening and full text screening - a total of 24 studies (13 human studies and 11 in-vitro studies) were included in this review (Figure 1).

3.1 Human Studies (Table 1)

3.1.1 Effect on Periodontium

The Population Assessment of Tobacco and Health survey (PATH) was a cross-sectional study conducted amongst 13,650 participating adolescents (aged 12 to 17 years) between 2013-16 in United States (US). It reported that between 2013-14, 1.7% of American adolescents self-reported current use of only e-cigarettes; 1.4% reported current dual use of both cigarettes and e-cigarettes whereas 7.1% of the participants reported past usage of both[11]. Atuegwu *et al.*, 2019 further compiled PATH survey data from 2013-16 (sample size = 23,670) and reported that e-cigarette users had increased odds of being diagnosed with gum disease (OR 1.76, 1.12–2.76) and bone loss around teeth (OR 1.67, 1.06–2.63) in comparison to never-users. The likelihood increased with history of usage of marijuana or non-prescribed drugs[12].

AR Rejaie *et al.*, 2018 assessed peri-implant parameters: Plaque Index (PI), Bleeding on Probing (BOP), Probing Depth (PD) and Marginal Bone Loss (MBL) using standardized digital radiographs; MMP-9 and IL-1β levels in peri-implant sulcular fluid *via* enzyme-linked immunosorbent assay amongst 32 cigarette smokers, 31 vaping individuals and 32 non-smokers. The Saudi-Arabian study reported a significant positive correlation between IL-1β and MBL in vaping individuals ($p = .0031$) with a suggestive conclusion that e-cigarette users have peri-implant inflammatory response which is greater in cigarette smokers[13].

A 2016 British pilot study reported an increase in gingival inflammation (assessed via BOP and cytokine level determination in saliva, GCF and serum via the Performance Fluorokine MAP cytokine multiplex kits) in tobacco smokers who switched from smoking to vaping for two weeks. The authors concluded that the result must be interpreted with extreme caution since it was pilot study[14].

Table 1. Human studies investigating effect of electronic cigarettes on oral tissues

Author, year	Country	Study design	Sample size	Outcome
Atuegwu*et al.*, 2019[11]	USA	longitudinal cohort study	23,670	Compared to never users, longitudinal electronic nicotine product users had increased odds of being diagnosed with gum disease (OR 1.76, 95% Confidence Interval (CI) 1.12–2.76) and bone loss around teeth (OR 1.67, 95% CI 1.06–2.63). Findings show that e-cigarettes may be harmful to oral health.
Akinkugbe *et al.* 2018[12]	USA	longitudinal cohort study	13,650	Ever use of cigarettes and e-cigarettes was associated with increased prevalence odds of self-reported past-year diagnosis with dental problems, although to a lesser magnitude. Dual use of e-cigarettes and conventional cigarettes is associated with poor oral health outcomes among adolescents.
ArRejaie*et al.*, 2018 [13]	Saudi Arabia	Cross-sectional	95	Increased levels of proinflammatory cytokines were seen in e-cigarette users suggesting greater peri-implant inflammatory response.
Wadia *et al.*, 2016[14]	UK	Pilot Cross-sectional	20	An increase in gingival inflammation was observered when cigarette smokers switched to vaping.
Bustamante *et al.*, 2018 [15]	USA	Cross-sectional	59	N'-Nitrosonornicotine (NNN) is an important carcinogenic tobacco-specific N-nitrosamine formed *via* nitrosation of the tobacco alkaloids nicotine and nornicotine. This carcinogenic nitrosamine NNN occurs in the oral cavity of e-cigarette users.
Mokeem*et al.*, 2018[16]	Saudi Arabia	Cross-sectional	154	The salivary cotinine levels were found to be significantly higher among the e-cigarette users.
Mokeem*et al.*, 2019[17]	Saudi Arabia	Cross-sectional	129	Oral *Candida albicans* was significantly higher among cigarette- and water pipe-smokers and e-cigarette users compared to the never-smokers.
Huilgol *et al.*, 2018 [18]	USA	Cross-sectional	4,56,343	A population-based study has reported that daily e-cigarette use, was independently associated with a 78% higher odds of poor oral health.
Bardellini*et al.*, 2018[19]	Italy	prospective case-control study	90	OMLs were detected in 55 cases, of which 19/55 (34.6%) belonged to group A and 36/55 (65.4%) to group B. Nicotine stomatitis, a hairy tongue and angular cheilitis resulted to be significantly more common among EC consumers.
Cho *et al.*, 2017 [20]	Republic of Korea	Cross-sectional study	65,528	E-cigarette use was associated with a significantly increased chance of either cracked or broken teeth, or tongue and/or inside cheek pain among adolescents
Harrison *et al.*, 2016 [21]	USA	Case Report	1	Explosion of e-cigarette was manifested as luxation of multiple teeth, multiple fractures of the maxillary anterior alveolus, burns on the dorsal surface of the tongue: coagulation necrosis of the superficial tissue and burns of the maxillary anterior gingiva and mucosa diffuse sloughing with frank ulceration
Brooks *et al.*, 2017 [22]	USA	Case Report	1	Explosion of e-cigarette was manifested as severe damage to the anterior dentition (fractured teeth, avulsions, luxation), had fractured the premaxilla and anterior nasal spine, and sustained lacerations to the upper lip, labial mucosa, gingivae, tongue, hard palate, and facial skin.
Rogér*et al.*, 2016 [23]	USA	Case Report	1	Explosion of e-cigarette was manifested as swelling of the upper and lower lips and hematoma on the right lower lip, laceration at the vermillion border of the lower lip, and mucosa mucosal thickening of the maxillary sinuses suggestive of inflammatory changes have also been reported after e-cigarette explosion.

3.1.2 *Effect on Saliva*

AUS-based study assessed salivary N'-Nitrosonornicotine (NNN), nornicotine, nicotine *via* liquid chromatography-tandem mass-spectrometry and urinary tobacco biomarkers, including total NNN (via liquid chromatography-nanoelectrospray ionization-high resolution tandem mass-spectrometry) in 20 e-cigarette users, 20 smokers and 19 nonsmokers. Nornicotine and NNN levels in e-cigarettes used by the study participants were also analyzed. NNN is an important carcinogenic tobacco-specific N-nitrosamine formed via nitrosation of the tobacco alkaloids nicotine and nornicotine. The mean of NNN in saliva of e-cigarette users was 14.6 (±23.1) pg/mL, with 80% of the smokers having salivary NNN in the range of levels found in e-cigarette users. In contrast, trace levels of NNN were found in e-cigarette liquids. The authors concluded that NNN is formed endogenously in e-cigarette users with overall exposure to NNN in e-cigarette users being dramatically lower than in smokers[15].

In a Saudi Arabian study, Mokeem *et al*., 2018 compared the clinical and radiographic periodontal parameters and whole salivary cotinine, interleukin IL-1β and IL-6 levels *via* ELISA amongst 39 cigarette smokers, 40 waterpipe-smokers, 37 e-cigarette users and 38 never-smokers. The mean whole salivary cotinine levels were reported to statistically significantly higher among cigarette - (247.6 ng/ml [227.6–263.4 ng/ml]; $P < 0.001$) and waterpipe-smokers (252.5 ng/ml [217.8–274.3 ng/ml]; $P < 0.001$) and individuals using e-cigarettes (221.6 ng/ml [2.9.4–252.4 ng/ml]; $P < 0.001$). Whole salivary IL-1β ($P < 0.01$) and IL-6 ($P < 0.01$) levels were statistically significantly higher among cigarette- and waterpipe-smokers compared with e-cigarettes users and never-smokers[16].

3.1.3 *Oral Candida*

Mokeem *et al*., 2019 in a Saudi Arabian study demonstrated that oral Candida carriage rates was significantly higher in cigarette- and waterpipe-smokers followed by e-cigarette users and the never-smokers (100%, 100%, 83.3% and 50% respectively). Thirty-four cigarette-smokers, 33 waterpipe-smokers, 30 e-cigarettes users and 32 never-smokers were assessed *via* Polymerase chain reaction (PCR)[17].

3.1.4 *Oral Hygiene*

A questionnaire-based population study of 456,343 US adults reported that daily e-cigarette use was independently associated with 78% higher odds of poor oral health (adjusted OR = 1.78, 95% CI: 1.39-2.30; $P < 0.001$)[18].

3.1.5 *Oral Mucosal Lesions*

An Italian prospective observational case-control study of 90 participants revealed that 65.4% of the e-cigarette users (n = 45) had oral mucosal lesions. Nicotine stomatitis, a hairy tongue and angular cheilitis were more common among e-cigarette consumers in comparison to former smokers[19].

In a cross-sectional study on 65,528 Korean students using self-reporting method, use of e-cigarettes was significantly associated with increased chance of either cracked or broken teeth, or tongue and/or inside cheek pain among adolescents[20].

3.1.6 *Oral Injury/Trauma*

Three independent case reports were found describing effects of e-cigarette explosion on the head and neck region including oral cavity. Avulsions, fractures and luxation of teeth; hematoma of lips, sinus mucosal thickening and fractures were reported in the alveolar process, premaxilla and anterior nasal spine following e-cigarette explosions. Two of the reported cases were of 18-year males and one of 28-year-old male. Two of the individuals were using e-cigarettes in an attempt for smoking cessation at the time of explosion[21,22,23].

3.2 In-vitro Studies (Table 2)

3.2.1 *Oral Epithelial Cells*

DNA damage due to EC aerosol or mainstream smoke extracts has been evaluated in cultured cell lines (human epithelial normal bronchial cells - Nuli1, human premalignant dysplastic oral mucosal keratinocyte cells - POE9n, and human oral squamous cell carcinoma - UM-SCC-1). The results indicated that the levels of oxidative DNA damage were similar or slightly higher after exposure to EC aerosol compared to mainstream smoke extracts and that EC aerosol depressed the expression of enzyme required for removal of oxidative DNA damage[24]. In-vitro analysis of EC aerosol-treated normal human oral keratinocytes show that EC aerosols are capable of inducing oxidative stress as indicated by significant decrease of intracellular glutathione (GSH) levels in a dose dependent manner[25].

E-cigarette vapor exposure has been found to alter morphology of human gingival epithelial cells, increase Lactate Dehydrogenase (LDH) level, increase apoptotic/necrotic cell percentage (increased caspase 3 activity) as compared to controls leading to dysregulated gingival cell function thereby causing gingival diseases. All of these deleterious effects were more in cells with repeated exposure and decreased following use of caspase inhibitors[26].

E-cigarette-exposed cells exhibit remarkably reduced cell viability and clonogenic survival, along with increased rates of apoptosis and necrosis in both normal epithelial cells and HNSCC cell lines independent of e-cigarette vapor nicotine content. Cells also exhibit significantly increased DNA strand breaks representing their genotoxicity[27].

Tomassi *et al.,* 2019 has reported presence of aberrant RNA transcripts within oral cells of both e-cigarette users and smokers. Disruption of various molecular pathways was found: "Wnt/Ca^{+} pathway" was the most common pathway affected in e-cigarette users and the "integrin signaling pathway" being the most affected in smokers. Both the groups showed deregulated genes in Rho family GTPases signaling pathway[28].

3.2.2 Gingival and Periodontal Fibroblasts

Alanazi *et al.,* 2018 demonstrated an altered morphology and reduced proliferation rate of human gingival fibroblasts and delayed fibroblast migration and wound healing upon repeated exposures to Cigarette Smoke Condensate (CSC) or to e-vapor condensates. CSC caused more damage to the fibroblasts in comparison to Nicotine Rich (NR) and Nicotine Free (NF) e-vapor condensates (Chain of damage CSC>NR e-vapor condensate>NF e-vapor condensate)[29].

Willershausen *et al.,* 2014 investigated the cell viability and proliferation of human Periodontal Ligament (PDL) fibroblasts in different e-smoking liquids. The proliferation rate of fibroblasts was reduced on incubating cells with nicotine or other flavored liquids of e-cigarettes with highest and statistically significant ($p < 0.001$) reduction was observed for menthol-flavored liquids. Significant decline in ATP detection within the fibroblasts was seen in hazelnut-flavored ($p < 0.024$), lime-flavored ($p < 0.009$) or menthol-flavored liquids ($p < 0.001$)[30].

E-cigarettes with flavors can cause increased oxidative/carbonyl stress, inflammatory cytokine release and DNA damage in human periodontal ligament fibroblasts and gingival epithelium. Oxidative/carbonyl stress via protein carbonylation results in stress induced premature senescence in gingival epithelium that may be one of the contributing factors in pathogenesis of oral diseases[31].

Human gingival fibroblasts have demonstrated increased levels of LDH, numerous vacuoles in the cytoplasm, a decrease in collagen I production and augmented LC3 II expression when exposed to nicotine containing e-cigarette fluid. Autophagic vesicles and more procollagen I molecules are more common in the cytoplasm of fibroblasts exposed to nicotine-free fluids[32].

3.2.3 Micro-organism Growth

An increase in *C. albicans* growth was observed with nicotine-rich e-cigarettes compared with non-exposed cultures. E-cigarettes may interact with *C. albicans* to foster their pathogenesis that may enhance the risk of candidiasis in e-cigarette users[33]. Flavorless aerosol ± nicotine also has a modest effect on oral commensal streptococci growth both as colonies on agar and as biofilms[34].

4. Discussion

Our review included a total 24 studies which included based population based and in-vitro studies. Various lacunae observed in the published literature were:

Majority of the published studies have been conducted in the Western countries and Saudi Arabia with studies from the Asian countries being extremely limited. It is imperative that other countries where use of e-cigarettes has been reported explore the sequelae of e-cigarette use as different topographical investigation may show variation in effects observed.

Large number of in-vitro studies causing adverse influence on oral tissues however culture results do not directly translate into clinically significant effects.

Many studies are limited to cigarette smoking and do not include effect of e-cigarettes on oral health.

There are multiple mechanisms of adverse effects on oral health by use of e-cigarettes. Gingival inflammation, periodontitis, bone loss and greater peri-implant inflammatory response are the attributes increased in response to exposure to e-cigarette smoke[11–14]. A number of in-vitro studies have examined the response of oral cells and tissues to e-cigarettes. These studies indicated effects

Table 2. In-vitro studies investigating effect of electronic cigarettes on oral tissues

Author, year	Country	Target cell	Method	Conclusion
Tommasi *et al*, 2019 [28]	USA	Oral cells	Investigated the regulation of genes and associated molecular pathways, genome-wide, RNA-sequencing (RNA-seq) analysis then canonical pathways and networks modulated were studied.	Deregulation of cancer related genes and associated molecular pathways such as Wnt/Ca^{+} pathway and Rho family GTPases signaling pathway present in the oral epithelium of e cigarette smokers.
Alanazi *et al*, 2019 [33]	Canada	e-cigarette vapor-exposed *C. albicans on* gingival epithelial cells	*C. albicans* growth and expression of different virulent genes, such as secreted aspartic proteases (SAPs), and the effect of e-cigarette vapor-exposed *C. albicans* on gingival epithelial cell morphology, growth, and lactate dehydrogenase (LDH) activity was studied.	Contribution of e-cigarette exposure to *C. albicans* overgrowth, and virulent genes expression, which could cause oral candidiasis in individuals carrying *C. albicans* and using e-cigarettes.
Alanazi *et al*, 2018 [29]	Canada	Human gingival fibroblasts	Human gingival fibroblasts were repeatedly exposed to cigarette smoke condensate (CSC) and to nicotine rich (NR) or nicotine-free (NF) e-vapor condensates which were used to perform various analysis.	Conventional cigarette smoke and e-vapor condensate negatively modulates gingival fibroblast activities. There is need to further investigate e-cigarettes as a possible factor contributing to cell damage and delayed wound healing.
Ganapathy *et al*, 2017 [24]	USA	Human oral and lung epithelial cells	Cells were exposed to e cigarette aerosol or mainstream smoke extracts and DNA damage was measured using various assays. Cell viability, reactive oxygen species (ROS) and total antioxidant capacity (TAC) were measured. mRNA and protein expression were evaluated by RT-PCR and western blot.	Exposure to EC aerosol suppressed the cellular antioxidant defenses and caused significant DNA damage. This may impose long term cancer risk.
Sancillo *et al*, 2017 [32]	Italy	Human gingival fibroblasts	Lactate Dehydrogenase Assay (LDH), electronic microscopy analysis, collagen I production, flow cytometry lysosome compartment evaluation and western blotting LC3 (microtubule-associated protein 1A/1B-light chain 3) expression were performed.	E-cigarette fluids (with and without nicotine) trigger molecular and morphological responses in oral fibroblasts, raising concerns about their role in the pathogenesis of oral diseases.
Rouabhia M *et al*, 2016 [26]	Canada	Gingival epithelial cells	Cells were exposed to e cigarette vapor, cell adhesion and morphology with inverted optical microscope and LDH activity, necrosis and apoptosis by different assays.	Alteration of gingival cell morphology and deregulation of function can provide explanation for periodontal disease and inflammation.
Sundar *et al*, 2016 [31]	New York	Human oral epithelial cells and periodontal ligament fibroblasts	Oxidative stress (by carbonylation), inflammation markers, DNA damage markers were measured by different assays.	E-cig with flavours causes increased oxidative /carbonyl stress and inflammatory cytokine release. Oxidative/carbonyl stress results in stress induced premature senescence in gingival epithelium which may contribute to pathogenesis of oral diseases

Ji EH *et al*, 2016 [25]	California	Normal human oral keratinocytes (NHOK)	Cytotoxicity in NHOK cells was determined by an ATP assay and then intracellular GSH was determined, quantitative real time PCR was done	Due to oxidative stress induced by toxic substances in e-cig aerosols (nanoparticles and chemicals) may lead to cytotoxicity of oral epithelial cells.
Yu V *et al*, 2016 [27]	USA	Normal epithelial and head and neck squamous cell carcinoma (HNSCC) cell lines	Cytotoxicity in these cells due to e-cig smoke was assessed using Annexin V flow cytometric analysis, trypan blue exclusion, and clonogenic assays. Genotoxicity in the form of DNA strand breaks was quantified using the neutral comet assay and c-H2AX immunostaining.	E-cigarette vapor, both with and without nicotine, is cytotoxic to epithelial cell lines and is a DNA strand break-inducing agent
Sancilio *et al*, 2016 [32]	Italy	Human gingival fibroblasts (HGF)	Cytotoxicity was analyzed by MTT assay. Apoptosis occurrence and Bax expression were evaluated by flow cytometry; ROS production was analyzed by fluorescence optical microscopy	Cytotoxicity exerted by e-cig on HGF is not entirely due to nicotine.
Willershausen I *et al*, 2014 [30]	Germany	Human periodontal ligament fibroblasts	Six test solutions with components from ECs were selected: lime-, hazelnut- and menthol-flavored liquids, nicotine, propylene glycol and PBS in control group. Cell viability, growth and morphology were measured and compared.	Menthol additives of e-smoking have deleterious effect on human periodontal ligament fibroblasts

on oral keratinocytes, gingival and periodontal fibroblasts adversely affecting their turnover rate, differentiation, morphology and increasing apoptotic rate[26,29–33]. Increased oxidative stress, proinflammatory and pro-senescence responses can result in dysregulated repair due to proinflammatory and pro-senescence responses in periodontal cells[32]. Disruption of cancer associated critical molecular pathways is reported by vapour use[28] which may promote oral mucosal field cancerization in the long run. Cases of oral and maxillofacial trauma caused by explosions or fire associated with e-cigarettes use are on rise. These types of injuries are unique to e-cigarettes relative to conventional smoking[21–23].

Many individuals consider that e-cigarettes help in smoking cessation but several longitudinal studies have shown that adolescents using e-cigarettes are more prone to shift to combustible cigarette smoking later in life leading to dependency[29].

The main limitation of this scoping review is the limited number of databases that were included in the search strategy. Bias may be present due to language limitation.

5. Conclusion

It would be premature to consider e-cigarettes as safe alternative tools for smoking cessation. Their use is detrimental to the oral health and may promote development of oral diseases. While the in-vitro studies indicate their potential for initial a malignant transformation, large scale population based data combined with molecular pathway analysis is required to assess the long-term effects and the safety of electronic nicotine products on oral health.

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