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# Electronic Cigarette Vapour and the Impacts on Oral Health: A Review

Nurul Wahida Mohd Hasan<sup>a,b</sup>, Badiah Baharin<sup>a\*</sup>, Nurulhuda Mohd<sup>a</sup>

<sup>a</sup>*Department of Restorative Dentistry, Faculty of Dentistry, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia*

<sup>b</sup>*Unit of Periodontics, School of Dental Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia*

\*Corresponding author: badiahb@ukm.edu.my

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## ABSTRACT

Electronic cigarettes (e-cigarettes) have been in demand among young generations as a modern way of smoking since last decade. E-cigarette devices generate the vapour through the heating process and the inhalation of vapour through the mouth which is known as vaping directly exposed the oral cavity to potentially toxic chemicals in the vapour. The e-cigarette vapour has been reported with potential systemic and oral health impacts though it is to a lesser extent than the conventional cigarette. The toxicity of the chemicals in e-cigarette vapour has been highlighted by various in-vitro studies and currently being explored by many researchers. Nicotine content in e-cigarette vapour not only causes addiction but has deleterious effects on the oral mucosa. E-cigarette vapour is commonly associated with oral health-related problems such as irritation to the oral mucosa, periodontal disease, and possibly the initiation of dental caries. As a marketing strategy, e-cigarette has been promoted as a safer way of smoking habit and use as a smoking cessation tools. Non-scientific assertions regarding e-cigarettes are causing public misunderstanding, leading people to assume that they are safe while the truth is yet unclear. This narrative review aims to emphasise the hazard of e-cigarette vapour and the outcome to oral health by summarising the evidence gathered from previous studies and the potential role of e-cigarette for smoking cessation aids considering the widespread usage of e-cigarettes and public concerns.

**Keywords:** *Aerosol; e-cigarette; nicotine; periodontitis; smoking; oral health*

## INTRODUCTION

E-cigarettes have been in the market and internationally commercialised since 2003 (Syx, 2014). The prevalence has been rising more rapidly in many countries such as United States, Russia and Germany including Malaysia. E-cigarettes smokers are frequently being called “e-smokers”

or “vapers” (Farsalinos *et al.*, 2013). E-cigarettes are regulated differently across the globe; in the United States, the Food and Drug Administration (FDA) has yet to receive approval as a smoking cessation aid (Lavacchi *et al.*, 2020). In Malaysia, the Ministry of Health classified electronic cigarettes containing nicotine under the Poison Act 1952 by differentiating the

e-cigarette (with nicotine) and vape (without nicotine). The sales and distribution of e-cigarettes in Malaysia are subjected under the Poison Act 1952 and Food Act 1983, Control of Tobacco Product Regulations 2004 (Ministry of Health Malaysia, 2015). According to the World Health Organization, people over the age of 15 years old accounted for 19% of smokers indicate the rise in the number of young smokers (World Health Organization, 2018). The impact of combustible cigarette smoking on the general and oral health of smokers around the world has been well-established causing major morbidity and mortality (Warnakulasuriya *et al.*, 2010). On the other hand, the long-term health impacts of e-cigarette studied in the United States and other regions of the world had reported cases of e-cigarette product use – associated lung injury (e-cigarette or vaping use-associated lung injury [EVALI]) which includes shortness of breath, fever and vomiting (Evans *et al.*, 2020). Similarly, there are potential consequences of e-cigarette vapour on oral health from the chemical content in the e-cigarette solution (e-liquid) even though only a few studies have reported the harmful effects (Holliday *et al.*, 2019). An e-cigarette is still considered a new product in the market and researchers are still gathering more evidence and investigating its long-term effects on oral health. E-cigarettes are expected to be less harmful as they are combustion-free but the aerosol from the vaporisation of e-liquids contains a wide range of harmful products (Grana *et al.*, 2014). FDA has reported e-cigarette cartridges and solutions contain nitrosamines, diethylene glycol and other contaminants potentially harmful to humans (Westenberger, 2009). The increase of dual smokers of both conventional and e-cigarettes as well as uncontrolled nicotine content is worrying (Leventhal *et al.*, 2015; McCabe *et al.*, 2019). Long-term and continuous exposure to these substances at a much greater level than in the air offers a major health concern for smokers and individuals indirectly exposed to e-cigarette vapour (Hess *et al.*, 2016). Therefore, the current evidence on oral health effects

of e-cigarettes vapour will be discussed reasonably including the critical overview of the available findings.

## MATERIALS AND METHODS

Relevant articles were independently searched on Medline, Web of Science, Scopus and Google Scholar up to March 2021. Only articles in English were considered. The keywords used were “smoking” OR “oral health”, “electronic cigarette” OR “oral health”, “electronic cigarette” OR “oral health” OR “smoking” OR “nicotine replacement therapy”, “electronic cigarette” OR “oral health” OR “smoking” OR “cessation”, “electronic cigarette” OR “periodontal diseases”, and “electronic cigarette” OR “dental caries”. Altogether, 261 articles were found; however, on the impacts of electronic cigarette to oral health only seven articles were thoroughly discussed.

### E-cigarettes and the Components

E-cigarettes are handheld device-driven designed with a battery, a refill tank that is made up of e-liquid and heating element that produce inhalable aerosol in either mods or pod system. The e-liquid mixture composed of propylene glycol (PG), vegetable glycerine (VG), artificial flavourings and nicotine with additional sweetener for locally manufactured e-liquid. Aerosol is defined as liquid or solid particles suspended in air and of a size that may allow inhalation into the lower respiratory tract (usually less than 10 micrometres in diameter) while the inhalable aerosol generated from e-cigarette devices composed of mainly nicotine and liquid mixture (World Health Organization, 2020). However, the easily available e-cigarette product is a concern nowadays as teenagers can easily purchase them online (Grana & Ling, 2014), and these products are commonly available in retail shops everywhere across the world (Hsu *et al.*, 2013). In Malaysia, it becomes a source of business among the locals, and this

is evidenced by the increase in the number of stores selling e-cigarettes and currently, there are no explicit restrictions limiting their sale and usage (Abdul Rahman *et al.*, 2019).

### **Nicotine in the Vapour and the Impacts to Oral Health**

Nicotine is the main chemical component in tobacco products as well as e-liquid and is a highly addictive substance potentially contributes to future drug abuse among the youth (National Institute on Drug Abuse, 2020). E-cigarettes can deliver nicotine at amount comparable to traditional cigarettes, as well as other potentially harmful aerosol components (Lopez *et al.*, 2016). The industry manufacturer has stated that a single e-cigarette device may accommodate a pack of 20 conventional cigarettes (Willett *et al.*, 2019). Nicotine is reported to be harmful by inhibiting osteoblast growth, impeding neutrophil phagocytosis, and promoting inflammatory cytokine release from human gingival fibroblasts at dosages equal to heavy smoking (Zhang *et al.*, 2019). Another study found nicotine not only harmful to fibroblast in culture but portrayed anti-proliferative effects (Rothen *et al.*, 2009). This suggests that nicotine-containing e-cigarettes impair oral myofibroblast differentiation in e-cigarette smokers, and thus their ability to heal wounds by inhibiting neovascularisation and reducing wound contraction by myofibroblasts (Lei *et al.*, 2017).

### **E-cigarettes Liquid Vapour and the Toxicity on Oral Cells and Tissues**

Toxicology studies have identified several hazardous components in e-cigarette such as nicotine, carbonyl, diacetyl, volatile organic substance, ultrafine particles and heavy metals like nickel, tin and lead (Wang *et al.*, 2019). In e-cigarette vapours, the reactivity of reactive oxygen species is equivalent to that of tobacco cigarette smoke (Lerner *et al.*, 2015). The evidence has been supported by Sancilio *et al.* (2017) who reported significant cytotoxicity and apoptosis induction to human gingival fibroblast cells

after exposure of e-cigarette vapours for 48 hours. When compared to controls, human periodontal ligament fibroblasts cells treated in e-liquid with menthol flavouring revealed a significant reduction in proliferation rates (Willershausen *et al.*, 2014). Another study using the nasopharyngeal tissues revealed cytotoxicity of both fruit-flavoured and tobacco-flavoured e-liquid (Welz *et al.*, 2016). The number of research examining the possible harmful effects of e-cigarette vapours on cells of oral mucosa is limited, as the clinical trials are conducted as a pilot study with small sample sizes. The long-term consequences of inhaled aerosols, as well as the possible antagonistic impact of e-cigarette components, remain unknown.

### **E-cigarettes Vapour and Periodontal Disease**

Smoking is one of the grade-modifier and established risk factors of periodontal disease (Tonetti *et al.*, 2018). A limited number of studies addressed the harmful effects of e-cigarette smoking on the periodontium and the evidence is conflicting. The positive impact to periodontium was reported when smokers change from conventional to e-cigarette (Tatullo *et al.*, 2016). On the contrary, Wadia *et al.* (2016) reported an increase in bleeding on probing score when tobacco smokers switched from smoking to vaping for two weeks suggesting recovery of gingival microcirculation which may activate gingival tissue metabolism and improve local host immune defence. Additionally, many studies have shown the negative impacts in e-cigarette smokers where they were more likely to have periodontitis, bone defect around teeth, and fractured teeth compared to non-smokers (Cho, 2017; Atuegwu *et al.*, 2019; Vora & Chaffee, 2019). Pro-inflammatory cytokines (IL-1 $\beta$  and prostaglandin E2) play an important role in periodontal inflammation. Studies have found no significant difference of pro-inflammatory cytokine in gingival crevicular fluid and saliva among e-cigarette smokers (Mokeem *et al.*, 2018; BinShabaib *et al.*,

2019). However, there are conflicting data on the levels of pro-inflammatory cytokines among e-cigarette smokers with dental implants which reported to have higher probing pocket depth, peri-implant bone loss, and proinflammatory cytokines levels (Al-Aali *et al.*, 2018; AlQahtani *et al.*, 2018). Regarding the environment in the mouth, the e-cigarette vapour may disrupt the ecology of the oral microbiome. A study on saliva analysis reported a predominance number of periodontal pathogens of *Veillonella* and *Porphyromonas* species in e-cigarette smokers compared with conventional cigarette smokers or non-smokers (Pushalkar *et al.*, 2020). Other than that, an in-vitro study had reported the exposure of nicotine-contained e-cigarette vapour to the human periodontal ligament fibroblasts showed an increase level of oxidative stress and pro-inflammatory cytokines, indicating a pathogenic mechanism (Sundar *et al.*, 2016). Despite the lack of substantial research, it is acceptable to conclude that e-cigarette smoking may negatively affect the periodontal condition and implant health.

### **E-cigarettes Vapour and Dental Caries**

High viscosity in e-liquid derived from the presence of propylene glycol and vegetable glycerine with combinations of sweetener and sweet flavouring chemicals may be the possible source of caries formation (Kim *et al.*, 2018). The presence of sucrose and sucralose as additives in e-cigarette liquids may expose e-cigarette smokers to dental caries (Tierney *et al.*, 2016). According to recent research, e-cigarette aerosol enhanced *Streptococcus mutans* adherence to enamel and encouraged biofilm development (Kim *et al.*, 2018). The presence of significant quantities of esters such as ethyl butyrate and triacetin in e-cigarette liquids was linked to bacteria-induced enamel demineralisation. However, more study is needed to find out which type of e-liquid that is highly associated with caries risk.

### **E-cigarettes Vapour and the Impacts on Oral Mucosa**

E-cigarette device may cause inflammation to the soft tissue such as injury to minor salivary glands from the heating process of vapour. As recently reviewed, several case reports showed the occurrence of mouth and tongue irritations in e-cigarette smokers (King *et al.*, 2019; Yang *et al.*, 2020). It was reported in the study, that after 30 days use of e-cigarette, the participants reported bleeding on brushing (17.1%) and oral ulcer (8.3%) more than those who did not use e-cigarette (Yao *et al.*, 2017). Furthermore, e-cigarette smokers had a higher rate of hairy tongue, nicotine stomatitis and hyperplastic candidiasis in the retro-commissural region than former smokers (Bardellini *et al.*, 2018). A study on dual and e-cigarette smokers reported that it was associated with self-reported poor oral health outcomes (Akinkugbe, 2019). Although most of the oral symptoms are self-reported with limited clinical study as well as scanty longitudinal data, still it can be justified that e-cigarette smoking is not safe for all age groups.

### **E-cigarettes as a Smoking Cessation Strategy**

Recently, e-cigarette companies are actively promoting e-cigarette as an option of smoking cessation aid as a marketing strategy and the effectiveness has been reported by a few studies (Liu *et al.*, 2018; Mohamed *et al.*, 2018; Hajek *et al.*, 2019). Clinical trial data showed that e-cigarette can be an effective smoking cessation assistance when it is used in a specific target group (Liu *et al.*, 2018; Hartmann-Boyce *et al.*, 2021). However, in large population-based research, it has shown contradictory results (Beard *et al.*, 2020). Contradicting evidence reported that teenagers who have started to smoke e-cigarette were more likely to smoke a conventional cigarette (Watkins *et al.*, 2018).

The increase in dual smokers brings so much concern as the exposure to nicotine gets higher and it is less likely for a smoker to quit smoking. Due to lack of longitudinal data, dentists must be informed that e-cigarettes are not to be chosen as a smoking cessation tool despite the positive effects reported in the cross-sectional and clinical trials.

## RECOMMENDATIONS AND KNOWLEDGE GAPS

Oral healthcare professionals need to play their roles by providing smoking cessation counselling and observe for any changes in the oral cavity. A thorough history of e-cigarette should be documented such as the e-cigarette device, e-liquid flavours and nicotine concentration. Though existing research implies that e-cigarettes are safer than conventional cigarettes, future study is needed to further understand the therapeutic implications by monitoring diverse groups of users longitudinally in properly planned clinical trials and supported by high-quality in-vitro experiments.

## CONCLUSION

The presence of chemicals in e-cigarette vapour, with or without nicotine, and extra flavouring compounds do not only affect periodontal ligament but also predisposes e-cigarette smokers to caries formation. The effects of e-cigarette vapours on oral health are unknown due to lack of long-term evidence and observation data. Given the variability of the products and the difficulty of detecting possible e-cigarette effects in individuals with a previous or/and present history of a conventional cigarette, exploring the oral health repercussions of e-cigarette use is a challenge for the researchers.

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