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Original Article

History of e-cigarettes use must be part of the dental patient records

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Statement of Clinical Significance

Recent studies have shown a significant increase in e-cigarette use worldwide, particularly among young adults. This narrative review focuses on key topics regarding e-cigarettes that should be introduced to dental professionals. We also suggest new methods for documenting patients' vaping habits in dental records. With this knowledge, dental students and practitioners can educate their patients more effectively. Additionally, to better understand the health impacts of e-cigarettes, it is crucial to document vaping habits and provide proper education and counseling to patients.

Abstract

Recent studies have highlighted a significant global increase in e-cigarette use, particularly among young adults. This narrative review targets the important topics related to e-cigarettes that should be introduced to dental professionals to review current knowledge of e-cigarettes, the impact on human health and the environment, and suggest incorporating this information into the dental school curriculum. Available literature was identified through searches of Medline/PubMed, SCOPUS, EMBASE, reference lists, and books, and was reviewed. The review showed that e- cigarettes are being used by young people who never smoked, and that the device may not be an effective form of tobacco cessation. It revealed the burden of the device on human health and the oral cavity, and the environment, suggesting the need to incorporate this information in the dental history forms. The findings suggest that there is a need to educate dental students on how to take history on patients who use e-cigarettes and how to counsel their patients.

Keywords: Electronic cigarettes; E-cigarette; Electronic nicotine delivery systems; Tobacco; Health, environment.

INTRODUCTION

Recent studies have shown significant growth in e-cigarette users worldwide, especially among young adults[1]. The initial purpose of the device was to be an alternative less harmful than conventional cigarettes, and a promising way to help smoking cessation[1]. However, growing evidence suggests that e-cigarettes are being abused by young non-smokers and are not helping smokers with smoke cessation[1]. Moreover, there is evidence in the literature of the negative burden of the product on human health[2-5] and the environment[6,7].

The present narrative review focused briefly on the history about e-cigarettes development and the objectives of the device. It presents aspects of the myriads of devices available to the consumer and their contents. The main focus of the review is on the importance of health educators' role in providing dental students and providers with skills on how to take histories from patients using e-cigarettes and learn the important steps of counseling patients[8]. Although we have developed excellent skills to take histories of tobacco use, the addition in our history-taking protocols of e-cigarettes use and vaping is still lacking. The need for this type of education cannot be overemphasized, when one considers the damage regular smoking has caused on humans and all the years that it is taking for health providers and administrators to change the scenario. We have a timely opportunity to prevent a similar health problem caused by regular smoking, by educating young health professionals about e-cigarettes and vaping and the damage it can cause to human health and the environment.

Search strategy and selection criteria

References used in this narrative review were identified through searches of Medline/PubMed (US National Library of Medicine, Bethesda, USA), SCOPUS (Elsevier, Amsterdam, The Netherlands), and EMBASE (Elsevier, Amsterdam, The Netherlands) with the search terms "history", "origin", "electronic cigarette", "electronic cigarettes", "e-cigarette", "e- cigarettes", "electronic nicotine delivery",

"vaping", "nicotine vaping products", "electronic nicotine delivery systems", "e-cigs", "e-hookahs", "mods", "vape pens", "vapes", "tank systems", "ENDS", without date restriction. Articles were also identified through searches of the authors' files, reference lists, and books. Only papers published in English and Portuguese were reviewed. Two authors independently reviewed the titles and abstracts of all references identified in the electronic databases and selected the articles that seemed to meet the inclusion criteria. The final reference list was generated based on originality and relevance to the broad scope of this Review.

RESULTS

E-cigarettes anatomy and purpose

E-cigarettes or electronic nicotine delivery systems (ENDS) as they are known today, were created in 2003 in China by the pharmacist Hon Lik[9]. The devices consisted of an internal battery that heated a fluid mixture (e-liquids or e-fluids) stored inside of a cartridge that produced an aerosol, or vapor, without the combustion produced by the burning of tobacco[9]. The purpose of the device was to be an alternative less harmful than conventional cigarettes, and a promising way to help smoking cessation. However, they are not currently approved by the US Food and Drug Administration (FDA) as a quit-smoking aid. The evidence is yet insufficient to recommend the product[10].

There are different generations of e-cigarettes. The first-generation of e-cigarette is physically very similar to a conventional cigarette. The fourth-generation e-cigarettes,

called pods, are devices with different shapes and colors. Figure 1

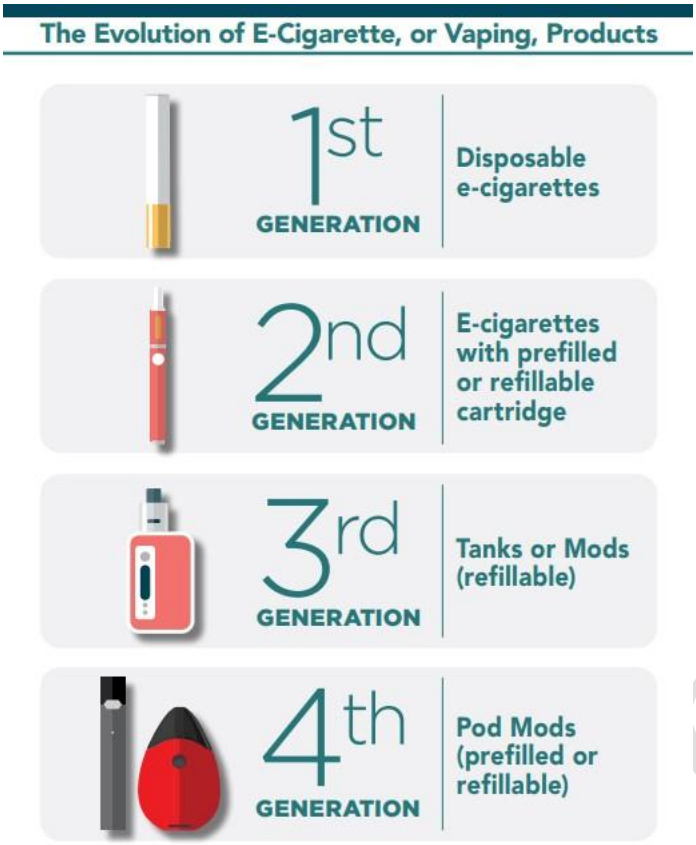

Figure 1. Generations of the e-cigarette[11].

shows the different generations of e- cigarettes[11]. Importantly, e-cigarettes can be rechargeable or disposable[9]. The aerosol contains several substances besides water[12]. In general, e-cigarettes can contain nicotine in different concentrations, vegetable glycerin, propylene glycol, flavorings, and cannabinoids (CBD and THC)[9]. There are also volatile organic compounds, such as formaldehyde, metals (e.g.tin, silver, iron, nickel), anthracene and more[13]. E-cigarettes are activated by the puff through sensors. Inside there is a battery that supplies power to the atomizer to heat the fluid to over 200 degrees Celsius (392 F). The atomizer is a coil that heats the liquid inside the cartridge and turns it into

aerosol particles in the air[9]. Figure 2

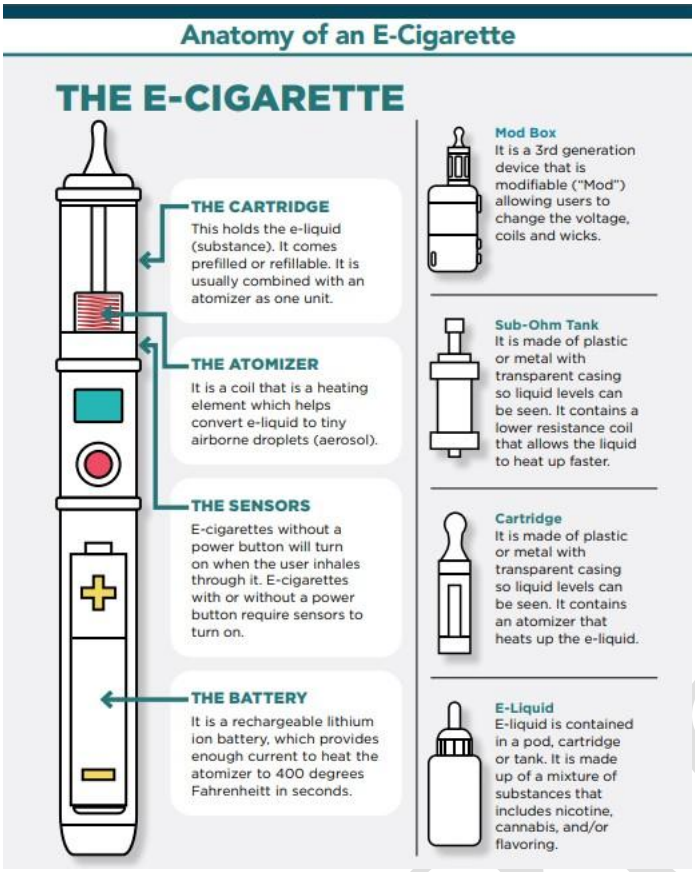

Figure 2. E-cigarette anatomy operation[11].

shows the e-cigarette anatomy operation[11].

E-cigarettes epidemiology

Studies have shown significant growth in e-cigarette users worldwide, especially among youth and young adults[1]. Current evidence shows that the age range with the highest percentage of e-cigarette users is between 18 and 24 years[14]. The Tobacco Atlas shows that the prevalence of e-cigarette users worldwide in adults ranges from 0.2–10.5%, while the prevalence of young users ranges from 0.7–29.9%[1].

Associated with this growth, the market of e-cigarettes is also growing aggressively using advertisement and social media. Users are being exposed to a variety of new devices, new technologies, and the introduction of new flavors[15]. E-cigarettes are sold in different shapes, colors, and models. In addition, there is a wide variety of flavors. These components are very attractive to young people. In fact, curiosity is reported as

one of the top reasons to attract e- cigarette users. Affinity toward the taste and smell of e-cigarettes is also a reason for initiating the habit. Adolescents are attracted to the fruity and/or dessert-flavored e-liquids. More than 80% of current users reported flavored e-cigarette use[16]. In addition, friends and family users, better price, and more accessibility compared to tobacco cigarettes influence the decision to start the habit[17].

Do e-cigarettes help smoke cessation?

There is an ongoing debate in the literature on whether e-cigarettes help smokers quit. A recent Cochrane systematic review suggested that there is evidence with moderate certainty that e-cigarettes with nicotine increase smoking cessation rates compared to nicotine replacement therapy (e.g. patch, gum) and e-cigarettes without nicotine[18]. However, the authors conclude that more studies are needed. E-cigarettes are not standardized. There are many varieties of the product. Hence, it is extremely difficult to generalize the efficacy of cessation based on clinical trials involving a specific e-cigarette as there are more than 400 different brands[15].

According to the CDC, in the 2020 Surgeon General's Report, for smokers to achieve any real health benefits from e-cigarettes, they would need to stop smoking any tobacco products completely and switch to e-cigarettes in order to achieve health benefits. Nevertheless, this is not what the studies have shown. Dual use means individuals who to try to quit smoking cigarettes start using other tobacco products or e-cigarettes but continue to smoke[19]. Caraballo et al. reported the prevalence of 10 smoking cessation methods commonly used by adult cigarette smokers and observed that 35.3% were using e-cigarettes. This percentage of e-cigarette use was higher compared to the use of other FDA-approved cessation aids. However, most e-cigarette users do not quit smoking cigarettes, instead, they use both products[20].

A recent meta-analysis showed that e-cigarette use among non-smoking young people was associated with four-and-a-half-fold higher odds of subsequently reporting becoming smokers[21]. Bertoni and Szklo reported that more than half of the individuals who have used e- cigarettes in their lives, or who currently use e-cigarettes, have never used conventional cigarettes. This data again raises the question of what the real purpose

of e-cigarettes is and who is the target population using e-cigarettes[22]. It is essential to reinforce the positive impact that anti-smoking campaigns have had in recent decades. According to The Tobacco Atlas, between 2007 to 2019 the percentage of smokers declined from 22.7 to 19.6%. Public policies, such as tax and price increases and smoke-free air laws, have obtained important results in reducing consumption[23]. On the other hand, we are seeing the exponential growth of e-cigarettes use, and despite this product being sold as a smoking cessation aid, studies are warning about the possible negative impact of the spread of these products, going against all the work and effort of anti-smoking policies[22].

The device delivers nicotine in the absence of burning tobacco. Contrary to the believe that e-cigarettes help a person to quit smoking, the current evidence shows that e-cigarettes may indeed stimulate the smoking habit among young people and hinder quit attempts of smokers[1]. Although e-cigarettes were developed to help smoke cessation, the evidence is yet insufficient to recommend the product for this purpose[19].

The impact of e-cigarettes on human health

Currently, several studies are showing the evidence of the negative impact of e-cigarettes on human health. As a relatively new product, there are several studies showing acute side effects of the device. Nonetheless, there is still a lot to explore, especially considering chronic exposure.

According to the CDC, the use of any tobacco products by youth, including e-cigarettes, is unsafe[3]. E-cigarette aerosol is not harmless, e-cigarettes with nicotine can cause lung and cell damage. Other negative effects include poisoning and immediate inhalation toxicity, and seizures, especially in children and adolescents[24].

Studies have shown that vapors produced by e-cigarettes can contain more than 2,000 toxic substances. Formaldehyde, tobacco alkaloids, tobacco-specific nitrosamines, anthracene, and heavy metals found in the product are carcinogenic and well known to damage health, similar to what is found in conventional cigarettes[13]. Despite this relevant information, the causal association between e-cigarettes and the development of cancer has not been well-established in the literature. Nonetheless, a

recent review reported that even though more evidence is necessary, e-cigarettes are implicated in DNA damage of oral mucosal cells[4].

The e-cigarettes are being associated with higher plaque index, increased periodontal pocket depth, severe periodontitis, changes in the microbiological composition of the subgingival biofilm (as occurs with smokers), potential to favor the virulence of fungus, stimulating its growth in the most aggressive form, and favoring the adhesion and accumulation of bacteria[25]. A recent systematic review observed that e-cigarettes have a potentially negative impact on peri-implant health[26].

In the respiratory system, e-cigarette users have reported several negative symptoms involving the nose, mouth, throat, and airways[2]. These included chronic bronchitis symptoms (chronic cough, phlegm, or bronchitis), sputum/wheeze, asthma, and asthma exacerbations[2]. Additionally, e-cigarettes are associated with a new disease called "e-cigarette or vaping, product use associated lung injury" or EVALI. Currently, anecdotal information suggested that one of the major causes of EVALI could be the tetrahydrocannabinol (THC), and/or the vitamin E acetate contained in e-cigarette products. The data available are not enough to rule out the association of other substances with EVALI cases[3].

A recent publication of the American Heart Association reported that early molecular and clinical evidence suggests several acute physiological effects from e-cigarettes, especially those containing nicotine[5]. Considering the acute effects, it was reported: platelet activation, thrombosis, endothelial dysfunction, coronary vasoconstriction, and ventricular arrhythmogenesis. In summary, these effects can lead to myocardial ischemia, myocardial infarction and increased myocardial demand for oxygen and nutrients[5].

Products of dubious origin, manufactured without quality standards, besides causing damage to the respiratory system, can lead to malfunctioning of the devices that can cause injuries and burns, largely due to the explosion of lithium batteries[27].

Taking history in patients who are using e-cigarettes (vaping)

Based on the evidence described above, taking histories of vaping patients', as part of the medical history review has become important. The usual procedure is to ask question about social habits such as smoking, using other tobacco products, drugs and alcohol intake. This has been well emphasized by dental schools around the country. However, we do not ask questions about e-cigarettes and vaping[28]. Patients feel that by replacing tobacco products with e-cigarettes, they no longer smoke. Thus, it is our obligation as health educators to teach the future professionals about e-cigarettes, so they will develop skills to properly educate their own patients.

New strategies have been suggested to address the habits of e-cigarette users. Taking that into account, our group recently published an editorial suggesting the incorporation of the following questions related to the vaping habits of patients in dental charts[29,30]:

1. Type: Patients should be asked about the specific type of e-cigarettes they use: the brand, if they are rechargeable or disposable. This improves understanding of the content of the device, the amount of nicotine inhaled and how many puffs the user can take per device;

2. Duration and frequency of use: Number of puffs from the device and average duration of each device until purchase of a new one or recharge of the current one. These information helps to better understand the intensity of exposure to the device;

3. Timing of Use: inquire about when patients usually use e-cigarettes (e.g., with friends, in stressful situations);

4. Concurrent Use: assess whether patients use e- cigarettes in conjunction with conventional cigarettes or other products, such as marijuana, alcohol;

5. General Health Symptoms (e.g. nausea, cough, fatigue, fever, chest pain, shortness of breath);

6. Oral Symptoms (e.g., dry mouth, changes in taste, sores, mucosal irritation)[30].

In summary, aspects that would be important in the history-taking process would include the education of patients about the e-cigarettes and their contents, the development of diseases, that have been associated with the device, the high nicotine content, the health effects of nicotine and other chemicals, and the importance of discarding the device properly to avoid environmental contamination[6,28].

The impact of e-cigarettes on the environment

In 2020, the FDA removed flavored pod-based e-cigarettes like JUUL from the market. As a result, the use of flavored disposable e-cigarettes increased significantly[6]. According to Tobacco Atlas, in the USA, in 2021, 53.7% of e-cigarette users use disposable devices[1].

E-cigarette waste contains components such as e-liquid containers, packaging, and batteries. The types of e-cigarettes waste reported in the literature are:

1. Plastic waste: Several e-cigarettes are disposable, single-use plastic cartridges, non- biodegradable, and poorly recyclable[6].

2. Electronic waste: Disposable e-cigarettes are frequently disposed of carelessly. These products contain printed circuit boards and lithium-ion batteries, which pose significant risks, including environmental contamination and the potential for explosions or fires[6].

3. Chemical waste: E-cigarette devices and e-liquid cartridges cannot be recycled with other plastic waste since they have nicotine residues[6].

A recent survey with 15 to 24-year-old reported that 68% of disposable e-cigarette users threw their empty devices in the regular trash, 13% dropped them in regular recycling bins, 9% littered them on the ground, and 8% sent them to electronic recycling facilities. Moreover, 19% of current e-cigarette users throw five or more devices in the trash every month. This behavior is contributing to the increasing global problem of electronic waste[7].

E-cigarettes should not be disposed of in the regular waste unit, or their liquid poured down the sink. In the case of the tobacco cigarette butt, the solution found for the waste was the introduction of measures to make tobacco companies responsible for reducing and managing this waste through a mandatory product stewardship scheme[29]. This issue should be addressed also by companies that produce e-cigarettes because they do not provide clear instructions to users on how to dispose the device[6].

Addicionally, regulatory agencies must collaborate to establish guidelines that facilitate the safe recycling and reduction of electronic waste from e-cigarettes. This issue requires urgent attention, as implementing product stewardship is an effective approach to hold e-cigarette companies accountable for their environmental impact and reduce pollution[7].

CONCLUSION

The findings of the present review suggest that it would be important to incorporate target questions concerning patients vaping habits in the dental curriculum, as well as developing teaching opportunities for students and providers. We suggest that our findings should be included in the history-taking forms as another social habit question, in addition to smoking, drinking and use of drugs. With this knowledge, dental students and providers can educate their patients. Furthermore, in order to better understand the impact of e-cigarettes on health, it is crucial to document the patients' vaping habits, and to provide them with proper education and counseling.

AUTHORS' CONTRIBUTIONS

BNFLM: conceptualization, formal analysis, investigation, methodology, writing – original draft, writing – review & editing. ACPR: writing – review & editing. TBB: writing – review & editing. ARSS: conceptualization, writing – original draft, writing – review & editing. KL: writing – review & editing. CAM: conceptualization, formal analysis, investigation, methodology, resources, supervision, visualization, writing – original draft, writing – review & editing.

CONFLICT OF INTEREST STATEMENT

Funding: We, the authors of this manuscript, declare that there is no financial relationship with any commercial association, current or within the past 2 years, which might pose a potential, perceived, or real conflict of interest. This includes grants, patent-licensing arrangements, consultancies, stock or other equity ownership, advisory board

memberships, or payments for conducting or publicizing our study. The authors also state the material is original, has not been published elsewhere, and is being submitted only to Journal of Oral Diagnosis.

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