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Impact of Electronic Cigarette on Public Health

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Abstract

The electronic cigarette (EC) is battery-powered electronic nicotine delivery systems that appear very similar to a conventional cigarette. EC is a rising phenomenon that is becoming gradually more popular among smokers worldwide. Vapers report use of EC helps them to quit smoking, and to reduce cigarette consumption. Although available evidence indicates that EC is safer alternative to smoking there is emerging data that suggests otherwise and that considerable health benefits are likely in smokers who switch from tobacco to EC. The key motivation among most of the vapers is smoking cessation (SC), however some use it for recreational purposes. Progression is often related to EC resembling traditional cigarettes, curiosity, and experimentation. Studies indicate that the content of the nicotine in EC is equivalent to oral nicotine replacement therapy products and causes minimal possibility of poisoning. The inhaled compounds associated with EC results in cytotoxicity and affect various organs. The considerable risk associated with the use and abuse of nicotine refill bottles has been reported. Large scale research will help make EC more effective as smoking substitutes. Although previous data shows that EC can considerably decrease cigarette consumption without causing significant side effects, there is emerging data suggesting the potentially toxic consequences of EC, which necessitates the urgent need for further research in that regard. The focus of the present article is use, the safety of EC and its effectiveness to provide as a long-term substitute for SC.

Keywords: Smoking; Electronic cigarette; Public health; Safety; Risk

Introduction

E-cigarettes (EC) are battery-powered devices that heat a solution of humectants to deliver an aerosol that is inhaled by the user [1]. The device was invented by Lik Hon in Hong Kong in 2003 [2]. Consumers have known it as "vaping" and the user is referred to as a "vaper." The liquid used in EC mainly consists of propylene glycol, glycerin, nicotine, flavorings, additives, and differing amounts of contaminants [3]. Currently, there are first, second, third and fourth generation devices [4]. Awareness and use of EC among smokers have increased exponentially in recent years, due to their capability to closely simulate the aesthetic and behavioral experience of smoking. EC delivers a dose of nicotine without involving the combustion of tobacco; therefore, it has potential roles in both smoking cessation (SC) and tobacco harm reduction (THR) [5]. EC users are likely to be younger, more educated, and have a higher income than non-users. Till now there has been a diverse regulatory response for the use of EC, hence more research on EC is required to ensure that the decisions of regulators are based on science. The review summarizes the outline on the categorization, use, safety, effectiveness for SC and regulatory issues of EC.

Literature Review

Basic design, structure and categorization of EC

EC is generally designed to resemble traditional cigarettes in dimensions and graphics to some extent (Figure 1) [6]. The key components are: the inhaler (cartridge), a disposable plastic mouthpiece, resembling a tobacco cigarette's filter, containing an absorbent material saturated with a liquid solution of propylene glycol and vegetable glycerin in which nicotine may be dissolved; the atomizing device (the heating element that vaporizes the liquid in the mouthpiece and generates the mist with each puff); and the battery component (the body of the device-resembling a tobacco cigarette – which houses a lithium-ion rechargeable battery to power the atomizer.

Types of ECs

Currently, the four different generations of EC available in the market are as follows [7]:

First-generation: Often called 'cig-a-like' and generally mimics the size and look of regular cigarettes and consists of small lithium batteries and cartomizers.

Second-generation: A "personal vaporizer" consisting mainly of higher-capacity lithium batteries and atomizers with the ability to refill them with liquid.

Third-generation: Also called 'Mods' from modification, consisting of very large-capacity lithium batteries with integrated circuits that allow vapers to change the voltage or power (wattage) delivered to the atomizer. These devices can be pooled with either second-generation atomizers or with rebuildable atomizers.

Fourth-generation: Most recent developed, powerful and innovative devices available. Together with the hardware for changing the voltage and/or the output in watts, it presents also mods with automatic

temperature control and the ability to manage very low resistances (sub-ohm).

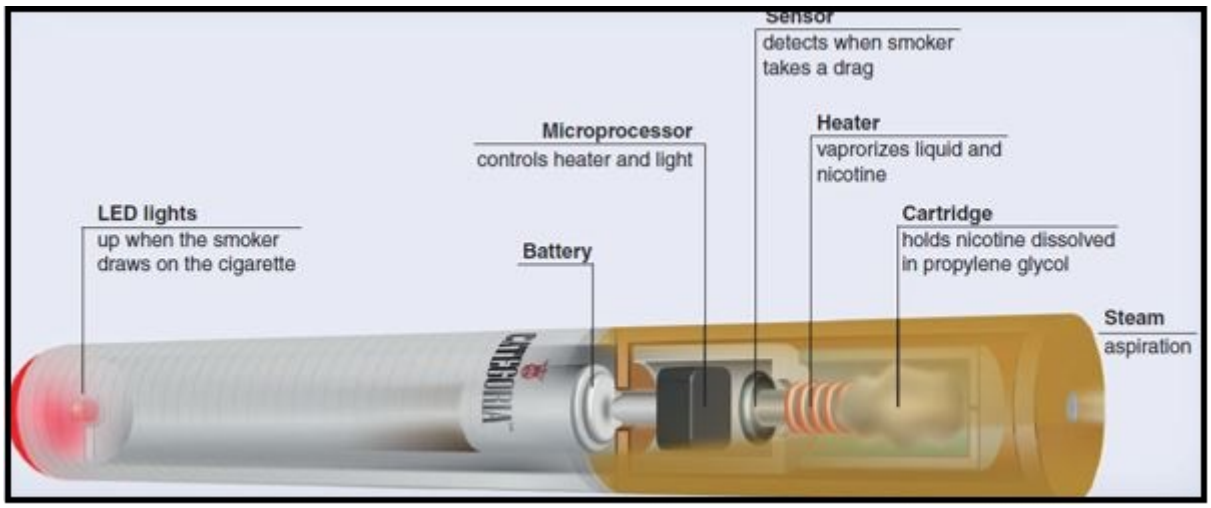

Figure 1: Structure of EC.

Users of EC and frequency

Ever since the availability of EC to market in 2003 [8], global use has risen exponentially. A 2013 four-country survey establishes there was usually greater awareness among white adult smokers compared with non-white ones [9]. The use of EC in the US and Europe is higher than in other countries [10]. In the UK, 5·7% of adults often use EC, about all of whom are smokers or ex-smokers [11]. A similar prevalence of EC use was reported in the USA [12]; however, it is lower in other European Union countries (average 2%) [11]. Daily vapers are typically recent former smokers [13]. Vaping is the largest among adults between 18 and 24 years of age. Greater than 10 million people vape daily, as of 2018 [14]. Among young adults, EC use is not regularly associated with trying to quit smoking [15]. Many women still vape during pregnancy because of their perceived safety in comparison with tobacco [16]. Nicotine, whether in the form of cigarettes or ECs, has the potential to cause teratogenic effects on the developing fetus [17]. Recent evidence supports that uses of ECs during pregnancy has the potential to cause similar harmful effects on offspring lung function and health as do conventional cigarettes [18].

Stimulus and progression

The major motivation of vapers is not to quit smoking, but mostly use it for leisure [12]. Predominately adults refer to three main reasons for the use of EC: as an aid to SC, EC as a safer choice to traditional cigarettes, and as a way to easily get around smoke-free laws [19]. A 2018 report documented smokers who previously vaped and quit, though, continued smoking, 51.5% of the documented smokers believed that vaping is less risky than smoking [20]. Non-smoking adults tried EC due to curiosity and college students often vape for experimentation [21]. E-liquid flavor availability is very appealing to EC users. Most vapers start with EC resembling traditional cigarettes, ultimately moving to a later-generation device. Users ranked nicotine strength as a key factor for choosing among various EC [22].

Safety profile of EC

Medical organizations differ in the view about the safety considerations of EC. A 2016 World Health Organization (WHO) reported scientific evidence for the effectiveness of vaping for quitting smoking is "scant and of low certainty" [23]. The European Respiratory Society stated in 2019 that although the cell cultures and animal studies have shown that ECs can have multiple negative effects, however, evidence from long-term safety studies are still lacking [24].

Clinical studies and surveys

None of the experimental or prospective follow-up studies reported serious adverse events (SAEs) associated with the use of EC [25,26]. A web-based survey reported that 82% of the participant did not think that ECs were completely safe, but holds the opinion that ECs were less dangerous than conventional cigarettes. Most of the adverse events (AEs) were mild to moderate, such as mouth and throat irritation and dry cough [27,28]. Two RCT studies reported, no significant differences in AEs between EC and control groups [29]. Studies reported short-term effects of ECs on the cardiovascular and respiratory system. Nicotine in EC increases heart rate after overnight abstinence [30], and five minutes of EC use generated an increase in airways resistance associated with a 16% decrease in fractional exhaled nitric oxide (FeNO) [31]. More data on e-cigarette safety and its efficacy in harm-reduction and smoking cessation are needed [26].

Nicotine levels and poisoning in EC users

Previous studies using a brief fixed puffing plan and smoker naïve to EC use found low or no nicotine delivery [32]. A boost of plasma nicotine delivery was reported (3.5 ng/ml) which was less than traditional cigarettes [33]. Studies show that EC poses minimal risk of nicotine poisoning from the device as intended to be used, but e-liquid can be dangerous or lethal if ingested, particularly by small children [34,35].

EC: A tool for smoking cessation

It has been estimated that smoking accounts for more deaths and diseases worldwide than any other modifiable risk factor [36]. Evidence suggests that approximately three-quarters of smokers want to quit, however, SC is difficult with frequent relapses common amongst those who try to quit smoking. The most common SC method is nicotine replacement, which address nicotine dependence [37]. Several studies reported possible roles of EC in both SC and THR [38,39]. The expansion in EC use has been accompanied by an increase in SC rates, a continued reduction in prevalence and no increase in smoking uptake. These findings indicate that EC may be an effective aid to SC, and therefore merits further evaluation for this purpose.

Potential for health benefits

EC offers benefits to vapers in the THR, the substitution of low-risk nicotine products for cigarette smoking. It may prove to be an even more attractive long-term alternative because of their similarities to smoking, including the hand-to-mouth repetitive motion and the visual cue of a smoke-like vapor [40]. Early results show indications that EC could be effective for helping long-term, inveterate smokers to become abstinent from inhaling smoke [40]. If sufficient numbers of smokers can transfer their nicotine dependence to the less-harmful EC, millions of lives could be saved [40]. The Royal College of Physicians has stated the possibility of alternative nicotine products being a safer cigarette smoking alternative as of now [41]. The EC may provide a safer long-term substitute to cigarette smoking.

Pros and Cons of EC

EC may provide evidence to be the most potential solution for the decline in the use of traditional cigarettes and their associated risk, with the positive attributes of these products evidently outweighing the negative features [40] (Table 1).

Pros	Cons
Not identified to cause fires or burns	Mislabeling and leakiness of liquid
Enhanced breathing and less coughing	Dry mouth and throat
Less toxic than tobacco smoke	Trace amounts of TSNAs present in some formulas tobacco-specific nitrosamines (TSNAs)
Mimics sensation in the throat of inhaling smoke	Throat sensation dependent on hardware used and liquid composition
Mitigate withdrawal symptoms and craving for tobacco	Relief of withdrawal symptoms varies, affected by quality of equipment and nicotine strength of liquid
No ash, dirt or burned clothes	Environmental distress regarding safe disposal of cartridges and batteries

Table 1: Pros and cons of EC.

Risk of EC

Toxic effects on humans

Tobacco-specific nitrosamines (TSNAs) are the strong carcinogens found in EC. 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK) and N'-nitrosonornicotine (NNN) are classified as human carcinogens (Group 1) by International Agency for Research on Cancer (IARC). Animal studies showed that N'-Nitrosoanabasine (NAB) (Group 3) contributes weakly to esophageal carcinogenesis. Carcinogens may be able to stimulate carcinogenesis and undermine "disease resistance" through modulating the immune response. A study documented significantly increased reactive oxygen species levels in EC, which were accompanied by the reduction in T lymphocytes proliferation rate in the spleen and thymus as well as reduction superoxide dismutase (SOD) levels in the spleen. Overall, this suggests the impairment of the immune system induced by formaldehyde [42,43].

Health effects related to specific components of EC

Glycol and glycerol vapor are components of the majority EC. Glycol mist may dry out mucous membranes and eyes. It's been reported that acute exposure to inhaled nicotine may cause dizziness, nausea, or vomiting. EC may augment the risk of nicotine toxicity due to the availability of high nicotine concentrations in the cartridges [44].

Effects on various organ system

A histopathological analysis showed excessive growth of aorta on nicotine exposure group [45] Liver biomarkers aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), and lactate dehydrogenase (LDH) rise on exposure to EC [46]. The occurrence of inflammatory response initiation, oxidative stress production and cytokine release were observed after Kupffer cells had been exposed to EC. It was suggested that EC exposure altered central nervous system development resulting in chronic neuropathy [47]. Mouth and throat irritation and dry cough were reported at primary use, though complaints decreased with continuing use [48].

Exposure risks for non-users

Children are at risk of toxicity from refill cartridges, as the flavorings may raise demand. The total nicotine content is potentially life-threatening. The refill solution component has cytotoxic effects on embryonic cells. Nicotine from the aerosol or the liquid could react with ambient nitrous acid to produce TSNAs, leading to inhalation, ingestion, or dermal exposure to carcinogens [49]. Although ECs have shown the potential to be an alternative to conventional cigarettes, and they are not devoid of health hazards. Some of the proven and potential risks [50-52] of EC are summarized below (Table 2).

Proven risks	Probable risk
Throat irritation and cough	Electrical accidents and fires
Respiratory resistance	Formaldehyde causing increased cancer risk

Elevation in diastolic blood pressure	Might increase TH2 airway inflammation and airway
Cytotoxicity	EC have secondhand and third hand effects
Nausea, vomiting, dizziness	Depending on heating degree, the toxic products can exceed the levels of combustible cigarettes
Skin, eye, and nasal irritant	Gateway to use of conventional cigarettes and illicit drugs
Acute cardiovascular damage	Immune suppression; may increase the virulence of bacteria

Table 2: Proven and potential risk associated with ECs.

Discussion and Future Research

The majority of healthcare professionals fear that EC might pose unforeseen acute or long-term complications. These complications may be attributable to the toxic or carcinogenic constituents of the vapor, deleterious effects on lung function, or some unexpected consequence [51]. While literature suggests that toxic compound levels generated by EC are much less than conventional cigarettes, it is still not clear if these levels are below the threshold of harm [53].

The detrimental effect of aerosols used in EC is well known but further research is needed to highlight the long-term complications [52]. Aerosols of EC contain toxic and irritant constituents, and its proinflammatory effect supported by studies warrants further research. Although the inflammatory effect of aerosols used in EC is much less than the conventional cigarettes, its impact on naïve lungs or non-smokers is still unknown. Studies must be conducted to predict future disease risk with EC in non-smokers [54].

Pisinger and Døssing raised the concern of academic bias in their meta-analysis. They claimed one-third of papers describing EC toxicity had a conflict of interest and that most studies are either funded or supported to some degree by EC manufacturers [55].

To assess the health impact of ECs compared to smoking in the clinical setting, long-term epidemiological studies are needed. The era of EC is just a decade old hence the epidemiology of long-term health effects is still not available [56]. At present, all studies conducted have only assessed short-term exposures and acute changes in health effects or biomarkers of recent exposures. Longer clinical trials and observational cohort studies with repeated measures are at the need of the hour. Although data is available on chronic effects on lungs, longer-term observational studies and clinical trials will provide definitive data in the future.

Regulations

Till date, there have been diverse regulatory responses ranging from no regulation to complete ban. The WHO's Study Group on Tobacco Product Regulation recommends a precautionary approach to EC and classifies EC as electronic nicotine delivery system [57]. Many national regulatory agencies have also adopted a similar stance. In the absence of specific recommendations for regulation, it is important that EC manufacturers and distributors must comply with the best possible quality standards. With strict regulation, EC may result in a safer alternative to traditional tobacco products.

Conclusion

Data to date show that EC may decrease cigarette consumption without causing significant side effects and reduces urges to smoke. Electronic Cigarette also provides a coping mechanism for conditioned smoking signs by replacing some of the practice associated with smoking gestures. However, the evidence is still unclear. Although previous data showed that EC can considerably decrease cigarette consumption without causing significant side effects, there is emerging data suggesting the potentially toxic consequences of EC, which necessitates the urgent need for further research in that regard.

Conflicts of Interest

There are no conflicts of interest for the present study.

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