

Effects of electronic cigarette smoking on human health

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Abstract. – OBJECTIVE: Electronic cigarette smoking is gaining dramatic popularity and is steadily spreading among the adolescents, high income, urban population around the world. The aim of this study is to highlight the hazards of e-cigarette smoking on human health.

MATERIALS AND METHODS: In this study, we identified 38 published studies through a systematic database searches including ISI-web of science and pub-med. We searched the related literature by using the key words including Electronic cigarette, E-cigarette, E-vapers, incidence, hazards. Studies in which electronic cigarette smoking hazards was investigated were included in the study. No limitations on publication status, study design of publication were implemented. Finally we included 28 publications and remaining 10 were excluded.

RESULTS: E-smoking can cause, nausea, vomiting, headache, dizziness, choking, burn injuries, upper respiratory tract irritation, dry cough, dryness of the eyes and mucous membrane, release of cytokines and pro-inflammatory mediators, allergic airway inflammation, decreased exhaled nitric oxide (FeNO) synthesis in the lungs, change in bronchial gene expression and risk of lung cancer.

CONCLUSIONS: Electronic cigarettes are swiftly promoted as an alternative to conventional cigarette smoking, although its use is highly controversial. Electronic cigarettes are not a smoking cessation product. Non-scientific claims about e-cigarettes are creating confusion in public perception about e-cigarette and people believe that e-cigarettes are safe and less addictive, but its use is unsafe and hazardous to human health. E-cigarette smoking should be regulated in the same way as traditional cigarettes and must be prohibited to children and adolescents.

Key Words:

Electronic cigarette smoking, e-smoking, Vapers, Health hazards.

Introduction

Electronic cigarette is also known as e-cigarette, a novel nicotine delivery system, invented in Republic of China in the year 2003^{1,2}. The e-cigarette smokers are commonly called “e-smokers” or “vapers”³. It is currently gaining marked popularity and steadily spreading among the youth, high income, urban population around the globe. The novelty of the technology, multiple attractive flavoring options, and marketing geared with variety of claims that e-cigarettes are non-toxic than conventional cigarettes, and facilitate to cigarette smoking cessation are appealing the youth to use e-cigarette⁴.

Despite major concerns from public health authorities, e-cigarette smoking has gained great popularity and acceptance by customers especially the teenage, and the sale is rising exponentially every year. E-cigarette industry is growing by leaps and bounds, and it may catch up with conventional tobacco in about a decade time. There are more than 200 e-cigarette brands available in the market, and sales were estimated to hit US\$ 3 billion in year 2013. It is estimated that global e-cigarette market could increase to US\$ 10 billion by 2017⁵. E-cigarettes are mostly designed to resemble traditional cigarettes in size, shape, appearance⁶, but some may be longer or shorter than a standard cigarette and resemble to fashion accessories like pen, pencil, lipstick, USB stick etc⁷. The main components for most e-cigarettes include an aerosol generator, flow sensor, battery and solution (e-liquid) storage compartment. The materials used in an e-cigarette include silver, steel, metals, ceramics, plastics, fibers, aluminum, rubber and spume⁶, and lithium made batteries, it may pose a risk of fire and explosion^{6,8}. Keeping in view the frequent use of e-smoking and public concerns, the aim of this study is to highlight the hazards of e-cigarette smoking on human health.

Materials and Methods

The present study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia.

Selection of Studies

In this study, we identified 38 published studies through a systematic database searches including ISI-web of science and pub-med. We searched the related literature by using the key words including Electronic cigarette, E cigarette, E vapers, incidence and hazards. In addition, we also entered the keywords in the google scholar search engine and after getting any related article, we re-entered the title of that article in the ISI-Web of Science and Pub-Med. The title and abstract of the studies were evaluated to determine eligibility for the documents. Studies in which electronic cigarette smoking hazards were investigated included in the study. No limitations on publication status, study design of publication were implemented. Finally we included 28 publications and remaining 10 were excluded.

Ethical Statement

In this study, we reviewed the data base literature on the Electronic cigarette, E cigarette, E-vapers, incidence, hazards; hence we did not require the ethical approval.

Results

Table I summarizes the common health hazards of e-cigarette smoking. E-smoking can cause, nausea, vomiting, headache, dizziness, choking, burn injuries, upper respiratory tract irritation, dry cough, dryness of the eyes and mu-

cus membrane, release of cytokines and pro-inflammatory mediators, allergic airway inflammation, decreased exhaled nitric oxide (FeNO) synthesis in the lungs, change in bronchial gene expression, and risk of lung cancer.

Discussion

The e-cigarettes do not burn or contain tobacco. The liquid used in e-cigarettes is generally nicotine with a wide range of flavors from fruits, mint, and chocolate⁹. The nicotine is carried through consumable cartridges which are available in various concentrations and can be adjusted to various levels of nicotine as per the requirements of the user. It may pose greater risk of nicotine toxicity while inhalation, ingestion or dermal exposure¹⁰. The heating device enhances the temperature of liquid in the cartridge and vaporizes the solution into an aerosol mist which the user inhales into the lungs through the mouth¹¹. There is a huge heterogeneity in the composition of e-cigarette products. The liquid in e-cigarettes commonly called e-liquid or e-fluid, is formulated to contain a mixture of chemicals, including nicotine. The chemical substances that have been present in e-cigarette refill solutions, cartridges and aerosols include tobacco-specific nitrosamines (TSNAs), aldehydes, metals, volatile organic compounds (VOCs), phenolic compounds, polycyclic aromatic hydrocarbons (PAHs), flavours, solvent carriers, tobacco alkaloids, and drugs (aminotadalafil and rimonabant). These compounds are harmful or potentially harmful constituents⁷. The current available literature suggests that the total nicotine in aerosol varies by brand from 0.5 to 15.4 mg per 300 puffs. However, in some cartridge 27 to 43 µg nicotine per 100 ml puff is available¹³. The environmental nicotine emis-

Table I. Frequent reported hazards of electronic cigarette smoking.

<p>Reparatory system: Upper respiratory tract irritation, dry cough, dryness of the mucus membrane⁴, nose bleeding, release of cytokines and pro-inflammatory mediators, allergic airway inflammation²⁰, decreased exhaled nitric oxide (FeNO) synthesis</p> <p>Nervous system: Headache, dizziness, nervousness, insomnia, sleeplessness²⁸</p> <p>GIT: Nausea, vomiting⁵, dry mouth, mouth or tongue sores/inflammation, black tongue, gum bleeding, gingivitis²⁸, gastric burning and constipation</p> <p>CVS: Palpitation, chest pain²⁸</p> <p>Eye: Irritation, redness and dryness of the eyes and can cause eye damage⁴</p> <p>Choking hazards: Accidental exposure to high concentrations of e-liquids can cause choking hazards²¹⁻²²</p> <p>Malignancy: Change in bronchial gene expression and risk of lung cancer¹⁹</p> <p>Miscellaneous: Shortness of breath, shivering¹⁰ etc</p>

sions from e-cigarettes also differ across the brands. The nicotine emissions from aerosols of different high-nicotine content e-liquids in cartridges was recorded to 538-8770 ng/l of nicotine in indoor air compared with 5039 to 48050 ng/l from conventional cigarette¹⁴.

The public believes that e-cigarettes are safer and less addictive than conventional cigarettes as they are being marketed with these claims. Presently, the public awareness is speedily increasing about the hazards of e-smoking. Nicotine found in e-cigarette is readily absorbed through the skin, mucous membranes, respiratory airway and gastrointestinal tract. Moreover, e-cigarette fluid poisoning exposure reported mainly in children through ingestion, inhalation, dermal exposure and ocular exposure¹⁵.

Respiratory System

The various chemical substances and ultrafine particles of e-cigarette cause irritation of pharynx, upper and lower respiratory system and dry cough⁴, some studies suggest that, it is known to be toxic and carcinogenic¹⁶. The glycol and glycerol vapors and mist components of e-cigarettes are known to cause dry mucous membranes, upper airway irritants⁴.

E-cigarette usually contains a propellant, such as propylene glycol, a respiratory irritant. The short-term pulmonary effect of the vapor of an e-cigarette is similar to that caused by the smoke of a cigarette and is a cause of broncho-restriction. Most of the brands contain glycerine, and a case of lipoid pneumonia has been reported due to this ingredient¹². Marini et al¹⁷ compared the short-term respiratory effects on exhaled nitric oxide (FeNO) due to the inhalation of electronic and conventional tobacco cigarette-generated mainstream aerosols. The mean FeNO values measured after each smoking/vaping session were equal to 3.2 ppb, 2.7 ppb and 2.8 ppb for electronic cigarettes lacking nicotine, with nicotine, and for conventional cigarettes respectively. Nicotine level decreases nitric oxide (NO) synthesis in the lungs and increases respiratory impedance and respiratory flow resistance¹⁸.

It has been demonstrated that, e smoking is known to be toxic and carcinogenic¹⁶. Electronic cigarettes can change gene expression in a similar way as tobacco smoking¹⁹; research has been conducted on human bronchial cells that contained some mutations found in smokers at risk of lung malignancy. Lim and Kim²⁰ reported that the inhalation of cartridge nicotine solution in e-

cigarettes is likely to exacerbate asthmatic symptoms by elevating infiltration of inflammatory cells including eosinophils into airways. This can enhance allergic airway inflammation and airway hyperresponsiveness, likely driven by the increase in the production of IL-4, IL-5, IL-13 and IgE²⁰.

Gastro Intestinal System

Exposure to inhaled nicotine may cause nausea, vomiting and dizziness. E-cigarettes, pose increased risk of nicotine toxicity due to the availability of high nicotine concentrations in the e cigarette cartridges. The level of nicotine exposure of e-cigarettes is highly variable and its liquids contain 14.8 to 87.2 mg/ml of nicotine.

Choking Hazards

Accidental exposure to e-cigarette products particularly exposure to e-liquids may have high concentrations of nicotine is associated with choking hazards²¹. Nicotine in high concentrations is toxic; injury or death may result if a young child ingests e-liquid or is dermally exposed to a significant volume of e-liquid²².

Ordonez et al⁵ reported 79 cases to e-cigarette fluid poisoning exposure mainly in children aged 5 years and younger. Exposures occurred through ingestion, inhalation, dermal exposure and ocular exposure. The patients reported with clinical features of nausea, vomiting, headache and dizziness.

Eyes

The e-cigarette vapors, mist, smoke are known to cause irritation, redness and dryness of the eyes⁴. As e liquid is rapidly absorbed; therefore, its exposure to eyes is very risky and can cause eye damage.

Brain

It has been identified that exposure to nicotine can cause neuroplastic changes in the brain²³. Nicotine interferes brainstem autonomic nuclei development during the prenatal period, alters the neocortex, hippocampus, and cerebellum during the early postnatal period and influences limbic system and late maturation during adolescence²³.

Reproductive System

Scientific literature has indicated that nicotine is harmful to both the mother and developing fetus, adversely affecting the fetus' developing ner-

vous system. E cigarette smoking delivers chemicals, some of which are well-documented reproductive toxins such as carbon monoxide. Zhang et al²⁴ reported that, smokers had a significant decrease in semen volumes, rapid progressive motility and sperm viability; moreover, smokers had a significant increase in the levels of immotile sperms and semen leukocytes. Sperm motion parameters were all lower in the smokers. The percentage of normal morphology sperm was decreased significantly in smokers, the sperm morphology was worse with increasing degree of smoking. Yu et al²⁵ demonstrates that, smoking is strongly associated with abnormalities in histone-to-protamine transition and alteration of protamine mRNA expression in human sperm. Furthermore, cigarette smoking reduces sperm plasma membrane integrity and consequently sperm motility²⁶.

Other Hazards

Nicotine is rapidly absorbed from the skin, mucous membranes, lungs and gastrointestinal tract. Nicotine in the e-liquids may pose greater risk of nicotine toxicity¹⁰. Christensen et al²⁷ reported a case of suicide attempt of a 13-year-old teen aged, who ingested 3 ml of nicotine liquid of unknown concentration. The patient developed nausea and shivering. Durmowicz¹⁰ reported that FDA-CTP received 74 reports with health effect complaints related to e-cigarettes. Three of the 74 reports involved children: death of an infant after choking on an e-cigarette cartridge, a 'spasm/dystonic' reaction (rhythmic right shoulder shrug). In addition, e smoking can cause, headache, sleepiness, sleeplessness, dizziness, gingivitis and black tongue.

Conclusions

Electronic cigarette smoking is increasing globally, although its use is highly controversial. It can cause nausea, vomiting, headache, dizziness, choking, shivering, burn injuries, upper respiratory tract irritation, dry cough, dryness of the eyes and mucus membrane, release of cytokines and pro-inflammatory mediators, allergic airway inflammation, decreased exhaled nitric oxide (NO) synthesis in the lungs and risk of lung cancer. It is suggested that, e-cigarette smoking is not safe therefore the e-cigarette smoking should be prohibited in closed public spaces and banned among children and adolescents.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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