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Chapter

What is e-Cigarette and Associated Health Risks

Narendra Maddu

Abstract

Tobacco is consumed in two forms named as smoking and smokeless tobacco. The electronic cigarettes are under the form of smoking tobacco. The electronic cigarettes (e-cigarettes) exposure has increased in recent years to the market. Many e-cigarettes contain nicotine, the primary most addictive agent in all tobacco products. We investigated the relationship between e-cigarettes and human health risks. These products may deliver sufficient nicotine for physiological responses and affects the all organs and tissues like nervous, cardiovascular, and pulmonary systems by exhibiting the effects of cytotoxic, decrease in heart rate, and extensive pulmonary damage. The e-cigarettes cannot be regarded as safe even though they are less harmful.

Keywords: electronic cigarettes, human health risks, smoking tobacco, e-cigarettes, nicotine

1. Introduction

The concept of the electronic cigarettes (EC) is quite old. It is developed in 1963 by Herbert Gilbert with a license under the name of smokeless non-tobacco cigarette. The device was first commercialized in China under the auspices of the Golden Dragon holdings. The technology of vaporization through a heating resistance was developed in 2009, and commercialized as an (ENDS) electronic nicotine delivery system [1]. EC also known as e-cigarettes, have become a popular alternative to cigarettes. The appearance of vaporized nicotine products widely referred to as electronic cigarettes or e-cigarettes (EC) has provided consumers with an alternative means of nicotine intake [2]. Information in this book has been taken from representatives of the Ministry of Health's or other regulatory body's verifications in the respective countries. There are 83 countries that have national/federal laws regulating e-cigarettes including laws related to the sale, age, advertisement, promotion, sponsorship, packaging with concern to health warning labeling and trademark, product regulation corresponding to nicotine concentration, safety, ingredients and flavors reporting taxation, use types and its toxicological evidences of e-cigarettes. Nicotine is not a carcinogenic agent, but it is a powerfully addictive substance.

The modern e-cigarette was invented in 2003 by Chinese pharmacist Hon Lik and as of 2018 most e-cigarettes are made in China [3]. Since they were first sold in 2004 their global use has risen exponentially [4]. In the United States and the United Kingdom their use is widespread. Reasons for using e-cigarettes involve trying to quit smoking, reduce risk, or save money, though some use them recreationally [5]. There are around 500 brands of e-cigarettes, with global sales in excess of US $ 7 billion [6].

2. What is e-cigarette?

The appearance of vaporized nicotine products widely referred to as e-cigarettes (EC) has provided consumers with an alternative means of nicotine intake [2]. An electronic cigarette or e-cigarette is also known as e-cigs, electronic nicotine delivery systems (ENDS) or electronic non-nicotine delivery systems (ENNDS), electronic smoking devices (ESDs), personal vaporizers (PVs), is a handheld electronic device that simulates the feeling of smoking. It works by heating a liquid to generate an aerosol, commonly called a "vapor", that the user inhales [4]. Using e-cigarettes is commonly referred to as vaping. The liquid in the e-cigarette, called e-liquid, or e-juice, is usually made of nicotine, propylene glycol, glycerine, and flavorings. Not all e-liquids contain nicotine. Most e-cigarettes contain a liquid, known as e-liquid or e-juice that contains a mixture of the following:
Water
Propylene glycol (PG)
Vegetable glycerin (VG)
Flavouring
Nicotine.
Different strengths of nicotine are available. The best way to assess the strength is by looking at the concentration which is expressed as milligrams of nicotine per millilitre of liquid (mg/ml), or a percentage (**Table 1**).

S. no	Strength	mg/ml	Percentage (%)
1	Nicotine free	0.0	0
2	Low	8.0	0.8
3	Medium	12.0	1.2
4	High	24.0	2.4
5	Highest	36.0	3.6

Table 1.
*Different concentration/percentage of e-cigarettes.*

3. Construction of e-cigars

An electronic cigarette is a battery-powered vaporizer [7]. The primary parts that make up an e-cigarette are a mouthpiece, a cartridge, a heating element/atomizer, a microprocessor, a battery, and possibly a LED light on the end. An atomizer comprises a small heating element that vaporizes e-liquid and wicking material that draws liquid onto the coil. When the user pushes a button, or (in some variations) activates a pressure sensor by inhaling, the heating element then atomizes the liquid solution. The e-liquid reaches a temperature of roughly 100–250°C (212–482°F) within a chamber to create an aerosolized vapor. The user inhales the aerosol, commonly called vapor, rather than cigarette smoke. The aerosol provides a flavor and feels similar to tobacco smoking. There are three main types of e-cigarettes:

1. cigalikes, looking like cigarettes;

2. eGos, bigger than cigalikes with refillable liquid tanks and;

3. mods, assembled with basic parts or by altering existing products.

First generation e-cigarettes tend to look like tobacco cigarettes and so are called "cigalikes" [8]. Most cigalikes look like cigarettes but there is some variation in size. Second generation devices are larger overall and look less like tobacco cigarettes. Third generation devices include mechanical mods and variable voltage devices. The fourth generation includes sub ohm tanks and temperature control devices. The power source is the biggest component of an e-cigarette, which is frequently a rechargeable lithium-ion battery [3] (**Figures 1** and **2**).

The majority of toxic chemicals found in tobacco smoke are absent in e-cigarette aerosol [9]. Those present are mostly below 1% of the corresponding levels in tobacco smoke. e-Cigarettes create an aerosol that can contain toxicants and traces
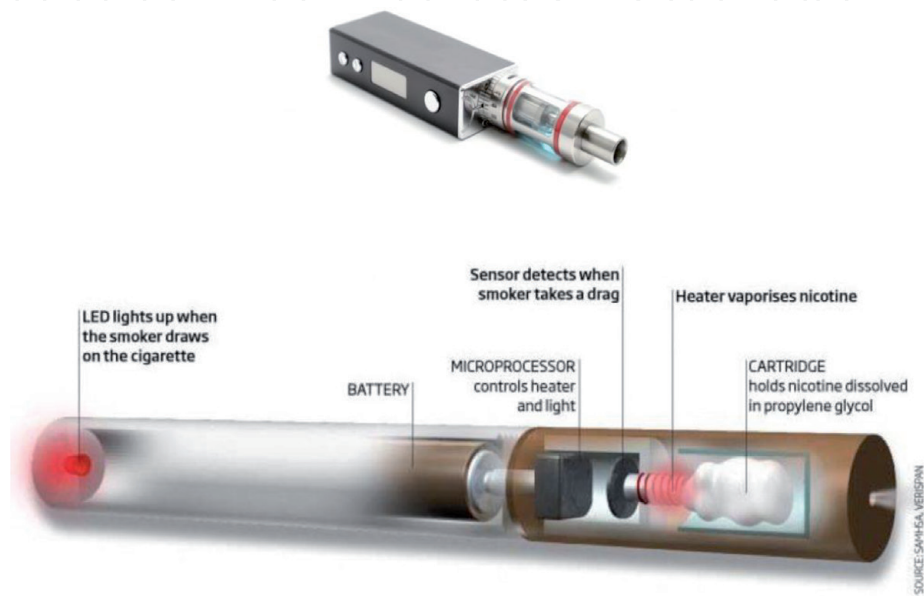
Figure 1.
Structure of e-cigar.

Figure 2.
Types of e-cigs.

of heavy metals at levels permissible in inhalation medicines [4] and potentially harmful chemicals not found in tobacco smoke at concentrations permissible by workplace safety standards.

4. Content of e-liquid

The liquid is composed of carrier solvents in e-cigarette, such as glycerol and/or propylene glycol. Aerosol generated from an e-cigarette is commonly but inaccurately referred to as 'vapour'. Vapour refers to the gaseous state of a substance; in contrast, an aerosol is a suspension of fine particles of liquid, solid or both in a gas form. Both the particulate and gases phase are mixtures of chemical substances in e-cigarette aerosols. The e-cigarette aerosol simulates cigarette smoke [10]. A puff of the aerosol is delivered into the user's mouth and lungs through inhalation, after which the remaining aerosol is exhaled into the environment [11]. These products are commercialised in various forms or 'models' with different design characteristics and generate different physical and chemical characteristics during operation.

e-cigarettes are becoming ever more popular, a concerning trend given limited information about their research. Marketers of e-cigarettes have made a variety of claims indicating that e-cigarettes are safer than conventional cigarettes and that their use facilitates smoking cessation [12]. However, e-cigarette manufacturers do not provide complete information on the chemicals used in the manufacturing process or the chemicals that may be released or synthesized during the aerosol generation process that occurs during use. Minimal valid research data are available on e-cigarette emissions. Furthermore, nicotine levels are intentionally formulated to create target strengths, yet measured levels may not match the label claim [13]. Consequently, safety concerns exist regarding e-cigarette user exposure to harmful and potentially harmful constituents (HPHCs), including nicotine, which has the potential to cause addiction and other adverse events [14].

5. Harmful chemicals in electronic cigarettes

While a limited numbers of studies have been conducted on EC to date, scientific studies have been identified hundreds of chemicals in the vapors of EC. About 42 chemicals are identified in the ECs, among which main stream smoke exposure can be especially harmful to health and some are emitted in the second hand smoke. They are listed in **Table 2**.

Main stream smoke	Second hand smoke
Acetaldehyde and acetone	Benzene
Acrolein	Farmaldehyde and benzaldehyde
Cadmium, nickle and lead	Diethylene glycol
Chromium	Nicotine and N-nitrosonornicotine
Phenol and propylene glycol	
O-methylbenzaldehyde	

Table 2.
Chemicals in e-cigarettes.

6. Frequency of e-cig users in global world

When the FDA commissioned their 2018 report on ENDS which they label as a Tobacco Product, the authors chose to use the term e-cigarettes for some use e-juice without nicotine [15]. At least 52% of smokers or ex-smokers in one area have vaped [16]. In the US, as of 2014, 12.6% of adults had used an e-cigarette at least once and approximately 3.7% were still using them [6], 1.1% of adults were daily users. Non-smokers and former smokers who had quit more than 4 years earlier were extremely unlikely to be current users [17]. In the UK, there were about 2.6 million users in 2015 which is about 18% of current smokers and about 5% of the population. About 59% of current smokers said they had tried them. In France in 2014, between 7.7 and 9.2 million people have tried e-cigarettes and 1.1–1.9 million use them on a daily basis. About 67% of French smokers use e-cigarettes to reduce or quit smoking. French people who have tried e-cigarettes, 9% have never smoked tobacco. Of the 1.2% who had recently stopped tobacco smoking at the time of the survey, 84% credited e-cigarettes as essential in quitting.

Although smoking among young people has declined over the last 5 years, this has coincided with a growth in the use of alternative nicotine products [18]. Some young people who have tried an e-cigarette have never smoked tobacco, so vaping can be a starting point for nicotine use [19]. The evidence on whether e-cigarettes are a gateway to tobacco smoking in later life is mixed and contradictory. e-Cigarettes, also known as vape pens, cartridges and pens, differ from traditional marijuana cigarettes in several respects. e-Cigarettes may be used with other substances and cartridges can potentially be filled with e-liquid containing substances other than nicotine, thus serving as a new way to deliver other psychoactive drugs, for example THC [20].

The amount of nicotine found in 13 inhalations from an e-cigarette with fluid containing 18 mg/ml nicotine was estimated to be equivalent to the amount found in a typical tobacco cigarette containing 0.5 mg nicotine [21]. Most medical organizations, including international organizations such as the WHO and those in the US, feel there is insufficient evidence to routinely recommend electronic cigarettes for use in smoking cessation [4] other medical organizations, particularly British ones, state e-cigarettes are a reasonable third-best alternative for smokers who are unable to quit. The available research on e-cigarette use for smoking cessation is limited. Some medical authorities recommend that e-cigarettes have a role in smoking cessation, and others disagree.

A 2016 meta-analysis based on 20 different studies found that smokers who vaped were 28% less likely to quit than those who had not tried electronic cigarettes. In the US, e-cigarettes have not been subject to the same efficacy testing as nicotine replacement products. Several authorities, including the World Health Organization, feel there is not enough evidence to recommend e-cigarettes for quitting smoking, and there are studies showing a decline in smoking cessation among dual users [22, 23]. Nicotine-containing e-cigarettes were associated with greater effectiveness for quitting smoking than e-cigarettes without nicotine. e-Cigarettes without nicotine may reduce tobacco cravings because of the smoking-related physical stimuli.

7. Adverse effects of vaping

The health risks of e-cigarettes are uncertain. Their long-term health effects are not known. When used by non-smokers, e-cigarettes can lead to nicotine addiction, and there is concern that children could start smoking after using e-cigarettes. So far, no serious adverse effects have been reported in trials. Less serious adverse effects include throat and mouth irritation, vomiting, nausea, and coughing.
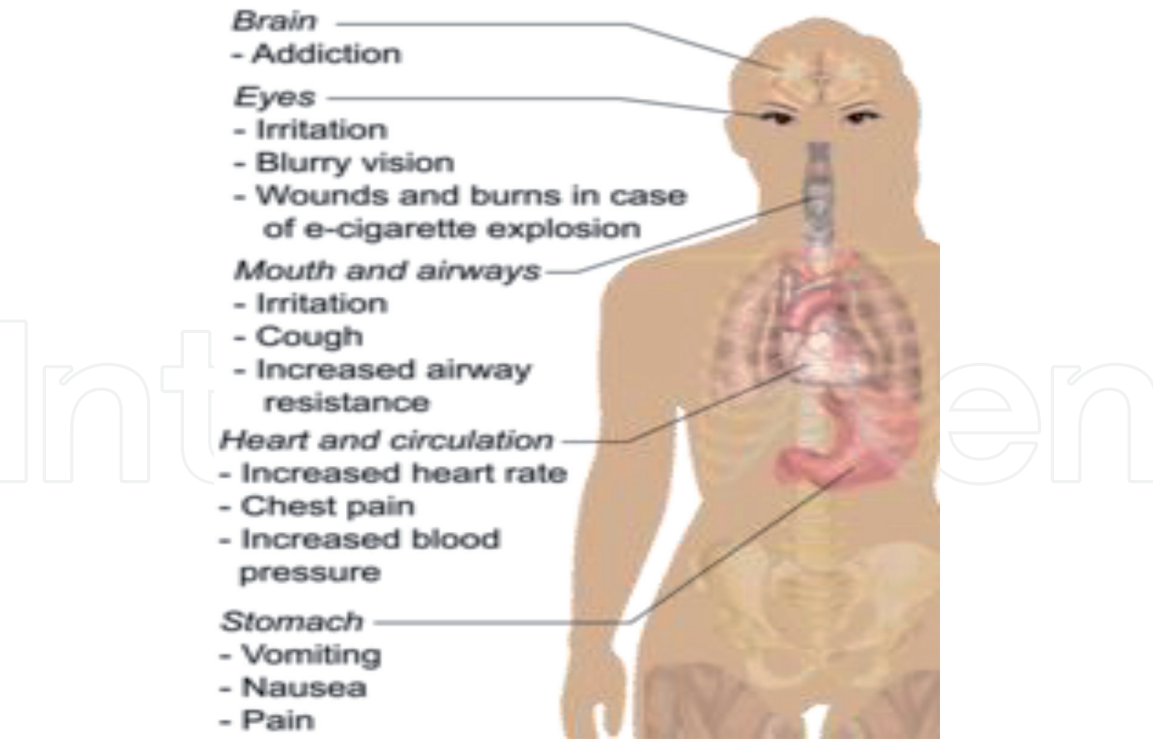
Figure 3.
Adverse effects of vaping on human health.

The European Commission recently concluded that the use of refillable electronic e-cigarettes, and the potential exposure to e-liquids containing nicotine in high strength, may pose harm to public health. It is found to exert adverse effects on lung and brain development in addition to the other parts. Nicotine can also have a little effect on human haemodynamics [19] (**Figure 3**).

Compared to conventional cigarettes, similar substances with potential carcinogenic or toxic effects are found in aerosol from electronic cigarettes, but in lower concentrations, whereas emitted reactive oxygen radicals appear comparable [24]. Although males more commonly reported any type of tobacco use as well as e-cigs, 9.5% of American high-school females reported current use of e-cigs, carrying a significant risk of using e-cigs in future pregnancies [25]. Although research is emerging around e-cigs in general, there continues to be a lack of scientific evidence regarding the safety and risks of e-cig use on maternal and fetal health, even though adverse health effects of nicotine on maternal and fetal outcomes are documented e-cigarettes, often touted as a safer alternative to cigarette smoking, may modify the DNA in the oral cells of users, potentially increasing the risk of cancer. Health risks conferred by smoking ordinary tobacco cigarettes include a number of non-communicable diseases, such as chronic obstructive pulmonary disease (COPD), lung cancer and cardiovascular diseases (**Figure 4**).

The long-term effects of e-cigarette use are unknown. Improvements in lung function and pulmonary health have been demonstrated among smokers who have switched to e-cigarettes [26]. WHO [4] reported that ENDS use poses serious threats to adolescents and fetuses. It is also thought that nicotine can create an increased risk of sudden infant death syndrome (SIDS). Other adverse outcomes include disruptive behavioral disorders, attention deficit hyperactivity disorder, reduced respiratory compliance, forced expiratory flow, and impaired lung function. It is also thought that electronic cigarette use can expose individuals to oxidants. Some studies have associated electronic cigarette use with an increased oxidative stress [27]. Aside from toxicity, there are also risks from misuse or accidents such as contact with liquid nicotine [28] (**Figure 5**).

Figure 4.
E-cigs—effect on the body parts.

e-Cigarette users who use e-cigarettes that contain nicotine are exposed to its potentially harmful effects [29]. Nicotine is associated with cardiovascular disease, potential birth defects, and poisoning. The vapor has been found to contain flavors, propylene glycol, glycerin, nicotine, tiny amounts of toxicants, carcinogens, heavy metals, and metal nanoparticles, and other harmful chemicals [19]. There is limited information available on the environmental issues around production, use, and disposal of e-cigarettes that use cartridges. Regulatory limits should be contemplated for levels of some of the more worrisome chemicals as well as for total flavor chemical levels.

Human and animal studies have found that nicotine exposure from e-cigarettes during adolescence adversely affects cognitive development [30], and animal research suggests that it has more severe impacts on the most vulnerable parts of the brain. One such region adversely affected by nicotine within the adolescent brain is the limbic system, which modulates drug reward, cognition, and emotion [31]. Nicotine is poisonous, and e-cigarette use or misuse can lead to nicotine poisoning via ingestion, inhalation, or absorption of nicotine via the skin or eyes. Early signs of accidental nicotine exposure include quickened tachycardia, diaphoresis, nausea,

Figure 5.
Swithing to e-cigarettes—not a healthy choice.

and vomiting, late effects include hypotension, hypoventilation and other effects include coma, seizure, respiratory, cardiac arrest and death.

As the usage of e-cigarettes increased between 2012 and 2015, the accidental nicotine exposure rate increased by 1398.2% in the US [32]. The absolute impact from passive exposure to EC vapor has the potential to lead to adverse health effects. The risk from being passively exposed to EC vapor is likely to be less than the risk from passive exposure to conventional cigarette smoke. Nicotine in tobacco smoke is absorbed into the bloodstream rapidly, and e-cigarette vapor is relatively slow in this regard [8]. e-Cigarettes have been advanced as a strategy to reduce the addictive levels of nicotine in cigarettes. Nicotine, a key ingredient in most e-liquids, is a highly addictive substance. Nicotine stimulates regions of the cortex associated with reward, pleasure and reducing anxiety. When nicotine intake stops, withdrawal symptoms include cravings for nicotine, anger/irritability, anxiety, depression, impatience, trouble sleeping, restlessness, hunger or weight gain, and difficulty concentrating. During pregnancy, the nicotine exposure increases the risk for eclampsia, premature birth, still birth, reduced birth weight, reduced lung function at birth, apnea, cleft lip and palate and probably effects muscle and skeletal development in the new-born child [33]. The nicotine content in e-cigarettes is adequate to cause or sustain nicotine dependence.

Systems toxicology investigations indicated that nicotine exposure also affected metabolic pathways the in liver, including upregulation of fatty acid beta-oxidation, cholesterol synthesis, gluconeogenesis, and ketone body formation pathways. Both standard and systems toxicology endpoints demonstrated very limited biological effects of propyleneglycol (PG), and vegetable glycerin (VG) aerosol with no signs of toxicity. Systems toxicology analyses detected biological effects of nicotine exposure, which included up-regulation of the xenobiotic-metabolizing enzymes CYP1A1 and FMO3 in the lung and metabolic effects, likely interlinked with a generalized stress response to nicotine present in the exposure aerosols [34].

Because e-cigarettes are relatively new to the scene, yet a very little research is available about how they impact the body. Still, numerous studies already offer crucial insights about how vaping might affect both your risk of type two diabetes and your management of the disease. However, the safety of e-cigarettes is debated, and a growing body of evidence is suggesting several adverse health effects. It's well known that traditional cigarettes can increase the risk of type two diabetes and related complications, but researchers are still analyzing the potential relationship between e-cigarettes and the disease.

e-Cigarette use is associated with a 42% increased risk of myocardial infarction, or heart attack, for which people with diabetes already have a heightened risk. Smoking e-cigarettes can lead to the mobilization of cells called endothelial progenitor cells (EPCs) to damaged blood vessels, a reaction that also occurs after people smoke traditional cigarettes. Over time, repeated and chronic mobilization of EPCs can actually deplete them. Lower levels of EPCs are also associated with both cardiovascular disease and type two diabetes. The nicotine in e-cigarettes could also affect blood sugar followed by hemoglobin A1C to rise by 34% that indicate a higher risk of complications from diabetes, including eye disease, heart disease, and kidney disease [35].

Nicotine and cigarette smoking is known to promote weight loss and suppress appetite. Since becoming available in 2007, the use of electronic cigarettes (e-cig) has increased dramatically in the US, however there are still very few studies that examine the long-term consequences of e-vapor, particularly in the context of appetite regulation or weight management [36]. The marketing of e-cigarette use as a safer alternative to cigarette smoking has led to an increasing use even in pregnancy. The nicotine consumed by e-cigarettes is similar to that consumed by cigarette smoking. Animal studies confirm the dangers of nicotine to the developing fetus. More research needs to be done specifically assessing e-cigarette use, pregnancy, and pregnancy outcomes [37].

In vitro studies have shown that cytotoxic effects vary among EC refill fluids. A few flavored chemicals (such as cinnamaldehyde) have toxicity at the concentrations used in EC [38], and stem cells are more sensitive than differentiated adult lung cells to EC products [39]. Recent studies have further shown that EC aerosols induced DNA strand breaks and reduced cell survival *in vitro* [40]. EC aerosols also reduced endothelial barrier function in cultured lung microvascular endothelial cells and increased inflammation and oxidative stress in mice [41]. Most case reports show that the health of children and adults can be negatively affected by EC products and that if death does not occur, negative effects can be reversed. Data further indicate that EC use can cause negative health effects in previously healthy individuals and exacerbate pre-existing conditions [42]. Research will help make electronic cigarettes more effective as smoking substitutes and will better define and further reduce residual risks from use to as low as possible, by establishing appropriate quality control and standards.

Mayer [43] suggested that the acute dose associated with a lethal outcome would be 500–1000 mg. Taking into account that voluminous vomiting is the first and characteristic symptom of nicotine ingestion, it seems that far higher levels of nicotine need to be ingested in order to have lethal consequences. However, due to the paucity of experimental data and contradictory evidence, it is difficult to draw conclusive outcomes regarding toxicological, immunological and clinical impacts of e-cig aerosols. Excessive vaping has been reported to induce inflammatory responses including mitogen-activated protein kinase, Janus tyrosine kinase/signal transducer and activator of transcription and nuclear factor-κB signaling, similar to that induced by tobacco smoke. Based on recent evidence, prolonged exposure to some constituents of e-cig aerosols might result in respiratory complications such as asthma, chronic obstructive pulmonary disease and inflammation.

A study using young healthy human airway epithelial cells showed that e-cigarette fluid promotes pro-inflammatory cytokine IL-6 production and human rhinovirus infection. Human lung fibroblasts exposed to e-cigarette liquid showed cell stress and other phenotypic abnormalities. A study in human embryonic stem cells also showed dysregulation of gene expression indicating a negative effect of e-cigarette use on heart development. Some studies found that at biologically relevant doses, vaporized e-liquids induced increased DNA strand breaks and cell death, and decreased

Chemical constituents	Permissible limit	Toxic effect	Molecular mechanism of toxicity	Reference
Acetaldehyde	45–270 ppm for 1 h	Eye, skin and respiratory tract irritation on acute exposure; pulmonary oedema and necrosis on higher exposures [46, 47]	Readily binds to protein and DNA, forming damaging adducts and impairing normal function and enzyme activity	[48, 49]
Acetone	750–1000 ppm per 8 h	Respiratory irritant in small quantities; CNS depression and cardiorespiratory failure in large amounts [50, 51]	Metabolism in high amounts is not possible, leading to its accumulation and toxicity	[50]
Acrolein	0.1 ppm per 8 h	Highly toxic respiratory and cardiovascular toxicant [51, 52]	Highly reactive, leading to DNA and protein adduction, endoplasmic reticulum stress, membrane damage, mitochondrial disruption, oxidative stress and immune dysfunction	[53]
Cadmium	5 µg m^{-3} of air for 8 h	Pulmonary changes with obstructive damage, renal dysfunction and teratogenicity in animals [54]	Interacts with DNA repair machinery, acts as a catalyst for ROS production, increases lipid peroxidation and induces apoptosis in cellular systems	[55, 56]
Chromium	0.5 mg m^{-3}	Nasal ulcers and perforations, lung and prostate cancers [57]	Under physiological conditions, can produce reactive intermediates, hydrogen peroxide and GSH, which can attack DNA, protein and membrane lipids	[58]
Formaldehyde	0.3 ng m^{-3}	Respiratory inflammation, pneumonia and bronchitis, neurological symptoms [57]	Highly reactive electrophilic reagent that can easily attach to neutrophilic biological targets, leading to formation of harmful adducts and ROS	[59]
Nicotine	0.5 mg m^{-3}	Hypertension, tachycardia, vasoconstriction, bronchorrhea, hyperpnoea [60, 61]	Toxicity attributed to oxidative damage, lipid peroxidation and DNA adduct formation	[62]
N-Nitrosamine	0.3 ng m^{-3}	Carcinogen [57]	Forms diazonium or oxynium ions which cause alkylating DNA	[63]
Toluene	200 ppm per 8 h	Neurotoxicity including euphoria, depression, cognitive impairment [64]	Metabolises to form hippurate ions resulting in metabolic acidosis and hypokalaemia	[65]
Lead	50 µg m^{-3} per 8 h	Neurotoxin, cardiotoxin, behavioral and developmental changes [66]	Causes oxidative stress and ionic imbalance	[67]

CNS, central nervous system; ROS, reactive oxygen species; GSH, glutathione.

Table 3.
Chemical constituents of e-cigarettes and its molecular mechanism(s) of toxicity.

clonogenic survival in both normal epithelial and head and neck squamous cell carcinoma cell lines independently of nicotine content [40]. Exposure to e-cigarette vapour also decreased the expression of cardiac transcription factors in cardiac progenitor cells, suggesting a persistent delay in differentiation [44].

Canistro et al. [45] found that e-cigs have a powerful booster effect on phase-I carcinogen-bioactivating enzymes, including activators of polycyclic aromatic hydrocarbons (PAHs), and increase oxygen free radical production and DNA oxidation to 8-hydroxy2'-deoxyguanosine. Furthermore, we found that e-cigs damage DNA not only at chromosomal level in peripheral blood, such as strand breaks in leucocytes and micronuclei formation in reticulocytes, but also at gene level such as point mutations in urine. Despite its short comings, the work presented here strongly raises the possibility that e-cig consumption under certain conditions leads to toxicological outcomes directly and indirectly damaging DNA in the rat.

After e-cig aerosol exposure, the overall lipid composition of rat plasma was markedly affected with significant increases in the content of esterified cholesterol, total cholesterol and triglycerides. Also observed a significant increase in cytochrome P450 (CYP)-CYP1A1/2, CYP2B1/2 and CYP3A to an enhanced cancer risk from the widely bioactivated e-cig vapour procarcinogens associated with an increased risk of lung cancer with CYP induction and/or CYP polymorphisms (**Table 3**).

Three categories of negative health effects were identified: systemic effects, nicotine poisoning, and mechanical injury. Systemic effects include respiratory, gastrointestinal, cardiovascular, immunological and neurological systems. Patients with negative effects were experiencing symptoms such as shortness of breath and cough. For the individuals with bronchiolitis, acute eosinophilic pneumonia, and pneumonia with bilateral pleural effusions, the onset of adverse health effects occurred within 3–7 days of EC use. Dyspnea, productive cough, mild tachycardia, exogenous lipoid pneumonia. Bronchial syndrome associated with deterioration of pulmonary function test, sub-acute bronchial toxicity, pleuritic chest pain [68]. Relapsed medically refractive ulcerative colitis, abdominal distention, respiratory distress, isolated chronic necrotizing enterocolitis. Asymptomatic acute and paroxysmal atrial fibrillation (AF). Acute myocardial infarction. Reversible cerebral vasoconstriction syndrome. Nicotine poisoning effects involves accidental poisoning, poisoning caused by intentional abuse or misuse and suicidal attempts which are symptomized by sudden onset vomiting, irritability, tachycardia, flushing, salivation and nausea, dizziness, mild tremor, shivering, cardiovascular resuscitation and full body seizures, multiple acute infarcts severe anoxic brain injury and death [69]. Mechanical injury caused by spontaneous explosion of EC battery. Also include oral trauma; tooth avulsion and severe mouth burns [70].

8. Harm reduction and safety

Awaiting future observations from current exposure must be taken into consideration when assessing harmful effects of e-cigarettes, and a precautionary principle is highly relevant. e-Cigarettes can reduce smokers exposure to carcinogens and other toxic substances found in tobacco, and are very likely less harmful than tobacco cigarettes [71]. This is a motivation for many e-cigarette users. The American Association of Public Health Physicians (AAPHP) suggests those who are unwilling to quit tobacco smoking or unable to quit with medical advice and pharmaceutical methods should consider other nicotine containing products such as electronic cigarettes and smokeless tobacco for long term use instead of smoking. The safety of electronic cigarettes is uncertain [22]. Tobacco smoke contains 100 known carcinogens, and 900 potentially cancer-causing chemicals, none of which has been found in more than trace quantities in e-cigarette vapor. A 2014 review recommended that regulations for e-cigarettes could be similar to those for dietary supplements or cosmetic products to not limit their potential for harm reduction [72]. A 2012 review found e-cigarettes could considerably reduce traditional

cigarettes use and they likely could be used as a lower risk replacement for traditional cigarettes, but there is not enough data on their safety and efficacy to draw definite conclusions.

9. Conclusions

Electronic cigarettes may help smokers stop their smoking, and the included studies did not find any serious side effects associated with their use for short duration up to 2 years. E-cigarettes are very limited and can be puzzling, so having the basic understanding of the mechanism of action, current regulation and health effects of this product. Impact on smoking cessation is unclear. Overall, the wide variability in products and lack of standardized testing methods makes evaluation of the available data in scientific community. It will be interesting to see the turn of events that e-cigarettes has in its role with tobacco users.

Conflict of interest

The authors report no declarations of interest.

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