Electronic cigarettes (ECs) are devices that vaporise and release a sweetened liquid containing nicotine as a substitute for burning tobacco. Manufacturers of ECs have suggested that ‘vaping’ is a safer alternative to conventional smoking because of the potential reduction in exposure to toxic substances. In the 2018 National Youth Tobacco Survey, 4.9% of middle school students and 20.8% of high school students reported using ECs in the previous 30 days, with respective rates of 0.6% and 1.5% in 2011 and 3.3% and 11.7% in 2017. The main reason for this steady increase in use of ECs in the younger age groups is the widespread perception that ECs are less harmful than conventional
cigarettes because they do not involve smoking of tobacco and contain less or no nicotine. This review suggests that ECs may not be as harmless as they seem. There are increasing numbers of case reports on the various complications arising from use of ECs, which are especially popular among young persons and could have a negative effect on their health.

The reported complications are lipoid pneumonia, acute eosinophilic pneumonia, hypersensitivity pneumonia, organizing pneumonia, diffuse alveolar hemorrhage, multiple reactive pulmonary nodules, subacute bronchiolitis, mouth and tongue injuries, dental injuries, complex facial fractures, thermal injuries, nickel contact allergy, C1 and C2 fracture, and fatal intoxication after ingestion of liquids. Complications that develop directly as a result of the substances contained in the devices and the adverse events resulting from explosion and burning of the device are being reported with increasing frequency. There is an urgent need for legislation and restriction regarding the sale of these devices in view of their increasing frequency of use in the younger age groups.

**Keywords:** e-cigarette, electronic cigarette, complications, health hazards, case report, head-neck injuries

**Introduction**

Electronic cigarettes (ECs) are devices that vaporise and release a sweetened liquid containing nicotine as a substitute for burning tobacco. Manufacturers of ECs have suggested that ‘vaping’ is a safer alternative to conventional smoking because of the potential reduction in exposure to toxic substances. The first-generation ECs were similar in shape to cigarettes, whereas the newer-generation ECs are produced in the form of pens, cartridges, boxes, lipsticks, USB sticks, or other everyday consumable products. ECs have various names, including e-cigs, e-cigars, e-shisha,
electronic hookahs, personal vaporizers, electronic vapor, vapes, vape pens, and atomizer tank systems.

The concept of ECs dates back to 1963 when Herbert A Gilbert received the first patent for a smokeless non-tobacco cigarette (1) that was intended to allow safe smoking of heated, moist, flavoured air without burning tobacco. Subsequently in 2003, Hon Lik, a Chinese pharmacist, invented the first e-cigarette, which became commercially available in China 1 year later (2). ECs were first sold in the US in 2007 but were not legally regulated until 2016 (3). During those years, manufacturers of ECs produced an increasingly wide range of designs. In the past decade, with the increased use of social media, ECs have become widespread globally and their use has increased exponentially. Consumption of ECs is being steadily encouraged by manufacturers, but in the absence of adequate legislation and regulatory control of devices and composition of e-liquids.

In 2015, the UK Department of Health reported that ECs were likely to be 95% less harmful than cigarettes containing tobacco (4). Moreover, in 2018, the American Cancer Association issued a position statement encouraging use of ECs rather than traditional methods of smoking (5). However, the European Federal Institute for Risk Assessment Institute and German Cancer Research Center have warned all countries about underestimating the potential dangers of ECs (6).

Between 2011 and 2017, use of ECs has increased significantly, especially among secondary school and high school students in the US (7). In the 2018 National Youth Tobacco Survey, 4.9% of middle school students and 20.8% of high school students reported using ECs in the previous 30 days, with respective rates of 0.6% and 1.5% in 2011 and 3.3% and 11.7% in 2017 (Figure 1) (7). The main reason for this steady increase in use of ECs in the younger age groups is the widespread perception that ECs are less harmful than conventional cigarettes because they do not involve smoking of tobacco and contain less or no nicotine.

Given the controversy surrounding the use of ECs, this literature review was undertaken to investigate the risks and complications associated with ECs.

Structure and properties
EC devices have an outer casing made of stainless steel and contain three inner components, i.e., a power supply (battery), an electric heating element (nebuliser, atomiser), and an aromatic liquid (cartridge) for evaporation (8). The largest component of the EC is the rechargeable power supply. Recently, lithium batteries and light-emitting diode lamps have been developed so that the devices can be lit during use. When an EC user breathes through the nozzle, a pressure-sensitive circuit activates the atomiser. The atomiser then heats the liquid in the cartridge and produces a smoke-like
vapour. The vapour is then drawn through the mouthpiece and exhaled by the user. Unlike tobacco smoking, combustion does not occur (9).

The cartridge typically houses a liquid consisting of propylene glycol and/or vegetable glycerine, water, and a sweetener. The resulting aerosol consists of fine and ultrafine liquid particles that may include formaldehyde, acetaldehyde, acrolein, and reactive oxygen compounds, as well as metals such as nickel, chromium, or lead, depending on the sweeteners and flavours added to the liquid (10). These pollutants are usually present in the EC aerosol in much smaller amounts than in tobacco smoke, but can also be present at similar or higher concentrations under certain operating conditions (10). Formaldehyde was found to be present in ECs in concentrations similar to those of as lead and chromium in tobacco cigarettes, while nickel was found to be present at higher concentrations (11). The properties and harmful effects of the substances in ECs are shown in Table 1.

More than 8,000 substances are presently used as flavours and aromas in ECs throughout the world, the most popular flavours being tobacco, mint, chocolate, and various fruits. ECs with strawberry, caramel, and gelatinous candy flavours are also marketed to cater for as many tastes as possible. However, very few of these flavouring substances have been tested for safety in humans.

A typical tobacco cigarette contains approximately 10–15 mg of nicotine, approximately 10% (1–2 mg) of which reaches the systemic circulation (12). The liquids used in ECs generally contain 14.8–87.2 mg/ml of nicotine, but may also contain less nicotine (0–36 mg/ml) or be nicotine-free (9,13). However, the amount of nicotine in the e-liquid that reaches the circulation varies depending on a number of factors, including duration and frequency of inhalation and the density of the vapour. In some samples, it has been observed that the nicotine content of the cartridge fluid does not match the amount stated on the label (13). In simulated EC use, the amount of nicotine per puff was reported to vary between 0 μg to 35 μg depending on the product (13,14). This finding indicates that about 30 puffs of an EC delivers 1 mg of nicotine, which is equivalent to the amount delivered by one conventional cigarette. A puff from an EC with the highest nicotine content delivers 20% of the nicotine content in a puff taken from a regular cigarette (13). However, the level of exposure to nicotine in EC users varies considerably.

Health hazards
The scientific evidence for the effects of ECs on human health is limited because of the wide range of products available and the small number of investigations performed. A review by Meo et al. mentioned that ECs can cause nausea, vomiting, headache, dizziness, suffocation, burns, upper respiratory tract irritation, dry cough, and dry eye, production of cytokines, release of pro-inflammatory mediators, allergic inflammation of the airway, decreased synthesis of nitric oxide in the lungs, and changes in gene expression in the bronchus, as well as increasing the risk of lung cancer (15). The main carcinogenic substances found in EC vapour are formaldehyde, chromium,
nickel, acetaldehyde, and tobacco-specific nitrosamines (11). Furthermore, propylene glycol and glycerine, the main components of the e-liquid contained in the cartridge, can irritate the eyes and respiratory tract, and prolonged or repeated inhalation in a manufacturing environment may affect the central nervous system, behaviour, and the spleen (11,16). The American Chemistry Council has warned against use of these substances to create fog in theatres because of their potentially harmful effects and that repeated use may have negative effects on the central nervous system (16). Moreover, recent research has shown that EC vapour has cytotoxic and oxidative effects as well as a negative impact on the functioning of alveolar macrophages (17), with the investigators calling into question the widespread opinion that ECs are harmless.

The most commonly encountered adverse effects of ECs are those concerning the impact of the inhaled liquids on the respiratory tract. The inhaled chemicals, particularly glycol and glycerol vapours and particulates, irritate the pharynx and the upper and lower respiratory tracts, and often cause dry cough (18). In one study, 27 healthy subjects without asthma experienced a 2% reduction in forced expiratory volume in 1 second (FEV$_1$)/forced vital capacity (FVC), an increase in FVC of 40 ml, and a decrease in FEV$_1$ of 30 ml as a result of acute exposure to propylene glycol for 1 minute (19). In another study that included 101 individuals working in environments that produce theatre fog, a 5% reduction in FEV$_1$ and FVC was reported in those who were working within 10 feet of the fog-producing machines (20). The results of these studies demonstrate the effect of these substances on respiratory function. However, although it is clear that EC vapour can cause acute bronchoconstriction, further research is needed. It has also been shown that EC vapour reduces synthesis of nitric oxide in the lungs and increases airway resistance (21). In addition to being toxic and carcinogenic, EC vapour also affects cell genetics in a tobacco-like manner (14). In a study conducted in mice, it was shown that EC vapour stimulates production of cytokines, including interleukin (IL) -4, IL-5, IL-13, and immunoglobulin E, and increases airway hyperreactivity by increasing allergic inflammation (22). These results suggest that EC vapour may be an important contributor to increased symptoms in patients with asthma.

Exogenous nicotine can cause nausea, vomiting, and dizziness depending on the dose inhaled or ingested. Furthermore, nicotine has been reported to exacerbate ulcerative colitis (23), and use of ECs may be associated with palpitations and chest pain, as well as paroxysmal atrial fibrillation and acute myocardial infarction (15,23). Nicotine has important effects on the nervous system, which can develop after use of ECs that contain nicotine. For example, nicotine inhibits prenatal development of the autonomic nuclei in the brain stem, causes changes in the neocortex, hippocampus, and cerebellum in the early postnatal period, and delays maturation by affecting the limbic system during adolescence (24). However, there has been a report of reversible cerebral vasoconstriction syndrome and headache in a person who was using ECs (23).

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The effects of ECs on the urinary tract can be expected to be similar to those of conventional cigarettes; however, the relevant literature is limited. Furthermore, the effect of ECs on the reproductive system has not been fully investigated. It has been shown that conventional cigarettes decrease semen volume and have a negative effect on sperm concentration and motility (15). There is also a report suggesting that the sweeteners in ECs could have a negative impact on sperm quality and damage the cells in the testicles that produce sperm (25). The same report concluded that the substance used to produce a cinnamon aroma slowed the motility of sperm and that a chewing gum flavour damaged the testicular cells that produce sperm.

Other adverse effects of nicotine include headache, insomnia, difficulty in falling asleep, dizziness, gingivitis, and black tongue, as well as a suicidal tendency in one report (15). It is also known that EC vapour causes ocular irritation and redness, along with dry eye (15). Therefore, continuous exposure of the eyes to these substances is hazardous and may cause permanent eye damage (26).

**Effect on smoking cessation**

It is believed that cigarette smokers can quit smoking or reduce the harm caused by continued smoking by using ECs. However, the results of many of the studies on the health benefits of transitioning from tobacco to ECs are conflicting (27). Few randomised double-blind studies have investigated the efficacy of ECs for smoking cessation. The evidence overall is classified as low or very low, so it is not possible to draw reliable conclusions based on the available research. However, it has been reported that nicotine-containing ECs may be a better choice for smoking cessation than nicotine-free ECs and can be as effective as nicotine patches (27). According to another report, ECs should not be recommended as effective smoking cessation aids until evidence of efficacy is presented (28).

**Complications of ECs**

ECs are becoming more popular than traditional cigarettes. Therefore, the numbers of notifications of side effects, complications, and case reports are increasing. Three international databases (PubMed, Science Citation Index, and Google Scholar) were searched for articles on the complications of ECs published between 2012 and 2018. The following key words were used: ‘e-cigarettes’, ‘electronic cigarettes’, ‘case report’, and ‘complications’. The case presentations are shown in Table 2 and are briefly summarised below.

**Report 1**

The first notification of mouth and tongue injuries caused by explosion of an EC device was reported in 2012. The case involved a 57-year-old man and was covered by CBS News (29).

**Report 2**

A 42-year-old woman was admitted to hospital with a 7-month history of dyspnoea, sputum production, and subjective fever. In the preceding months, she had completed multiple courses of
antibiotic treatment. The patient's complaints coincided with starting use of ECs. Computed tomography (CT) scans revealed a “crazy-paving” pattern in the upper and lower lobes bilaterally with signs of interlobular septal thickening. Bronchoscopy and bronchoalveolar lavage (BAL) revealed 48% neutrophils, 43% monocytes, 8% lymphocytes, and 1% eosinophils. Bacterial and viral cultures were negative. A large amount of lipid-laden macrophages secondary to chronic inflammation was detected on further examination of BAL. The diagnosis was lipoid pneumonia. Most EC brands contain glycerine, and it is thought that inhalation of this substance can cause lipoid pneumonia (30).

Report 3
In 2014, a 43-year-old patient with a diagnosis of lung adenocarcinoma (stage pT3N0M1b) who had been smoking 20 cigarettes a day decided to switch to ECs on a friend's advice in an effort to quit smoking (31). The patient vaped about 25 times daily using a liquid containing 19 mg/ml of nicotine, taking 5–6 puffs each time. According to the packaging, the liquid in the EC product contained glycerol (<90%), purified water (<10%), food flavouring, tobacco flavouring, and nicotine. After 48 hours of vaping, the patient started coughing up whitish secretions and developed progressive shortness of breath over a period of 1 week. The FEV1 was found to have decreased from 3.06 l (73.7%) to 1.87 l (45.2%). The patient was diagnosed to have subacute bronchial toxicity caused by use of an EC (31).

Report 4
A 20-year-old man with no history of being unwell was admitted to hospital after 3 days of persistent cough, shortness of breath, and facial flushing. His symptoms had started an hour after using an EC. The patient was found to have mild leucocytosis, and a chest radiograph showed subtle diffuse patchy reticulonodular opacities. CT of the lungs revealed diffuse ground-glass opacities that were more common in the upper and middle lobes than in the lower lobes. Large amounts of macrophages, eosinophils, and scattered benign respiratory epithelial cells were detected in BAL fluid. The cell count showed 3% neutrophils, 2% basophils, 17% macrophages, and 74% eosinophils. No evidence of bacterial, viral, fungal, or parasitic infection or of a neoplasm was found on bronchoscopy, culture, or serum laboratory tests. The patient was diagnosed to have acute eosinophilic pneumonia and treated successfully with a corticosteroid (32).

Report 5
A 43-year-old man who had vaped hundreds of times a day for three consecutive days was admitted to hospital with acute dyspnoea, pleuritic chest pain, and tachycardia. Physical examination revealed bibasilar crackles. The influenza panel was negative for influenza A and B. A chest radiograph
revealed hypoinflated lungs with bibasilar parenchymal consolidation and associated pleural effusions bilaterally (33).

**Report 6**
A 30-year-old man sustained partial thickness burns to his right foot and knee after an EC battery exploded in his trouser pocket (34).

**Report 7**
A 52-year-old woman presented to hospital with an 8-month history of pruritic erythematous dermatitis on her right hand, which coincided with starting use of ECs. A dimethylglyoxime nickel spot test was positive. The patient reported holding the device with her right hand. The device was found to be worn and to be releasing nickel as a result of sweating of the hands. Thus far, this is a unique report of contact allergy attributed to ECs (35).

**Report 8**
A 24-year-old woman was brought to hospital after intentionally swallowing 3,000 mg of liquid nicotine intended for use in ECs. The patient was unconscious on admission and subsequently died despite cardiopulmonary resuscitation and aggressive support. Toxicology tests performed after resuscitation reported a plasma nicotine level of >1,000 ng/ml and a high cotinine level. Magnetic resonance imaging revealed multiple acute infarctions consistent with severe anoxic brain injury (36).

**Report 9**
A 45-year-old woman with no significant medical history was admitted to hospital for suspected dissemination of malignant disease. She had a 4-week history of abdominal pain and intermittent low-grade fever. A full-body CT scan revealed multiple nodules in the lungs and multiple metastatic lesions in the liver. The patient, who had a 20 pack-year history of smoking, had been using ECs (10 mg, 38 mg/ml) for the previous 20 months. A liver biopsy showed non-specific reactive changes. Positron emission tomography confirmed a positive tumour response. A small tumour was then resected thoracoscopically. The biopsy revealed inflamed lung tissue with no evidence of malignancy. Re-examination of the lung biopsy specimen revealed an area containing multinucleated giant cells, suggesting a foreign body reaction consistent with the glycerine-based fats found in droplets from EC vapour. The findings in this patient were thought to have developed secondary to exposure to glycerine (37).

**Report 10**
A 26-year-old man who was a paid tester for an EC company sustained injuries after the battery in an experimental device he was testing exploded, causing the device to disintegrate and scatter like
shrapnel. He was admitted to the emergency department by ambulance with burns to the upper abdomen, left shoulder, and chest (38).

Report 11
An 18-year-old man was admitted to hospital with oral and abdominal burns, oral lacerations, tooth fractures, and dental avulsion after an EC exploded in his mouth (39).

Report 12
In 2016, two cases of bilateral corneal burns, corneoscleral laceration, and prolapsed iris tissue were reported after explosion of an EC device. The patients were aged 45 years and 16 years (26).

Report 13
A 59-year-old man with leukaemia, hyperlipidaemia, chronic back pain, and right hearing loss presented to hospital after explosion of an EC while he was vaping. The patient had bought the device via the Internet and had been using it for 2 days. He complained of epistaxis, blurred vision in his right eye, and hearing loss on the left side. A CT scan showed petrous, ethmoid, cribiform plaque, nasal choana, nasal septal, and right medial orbital wall fractures accompanied by pneumocephalus (40).

Report 14
A 20-year-old man was admitted to hospital with projectile point fractures of the anterior/posterior frontal sinus and right naso-orbital-ethmoid complex as a result of malfunction and explosion of an EC. The battery was dislodged and a flare of up to a few meters was observed at the time of the explosion (41).

Report 15
An 18-year-old man presented to a clinic with extensive injuries to the teeth and intraoral soft tissues. The patient stated that a sudden explosion had occurred immediately after he had filled an EC with e-liquid after having left the lithium ion battery to charge overnight. The device had exploded while he was placing the device in his mouth (42).

Report 16
A 42-year-old man was admitted to hospital with a cardiac arrest and poor neurological function. The information available suggested that he had swallowed a large amount of e-liquid containing nicotine. On admission, he had a plasma nicotine level of 3.0 mg/l (reference range for smokers, 0.01–0.05 mg/l). The patient died of post-anoxic encephalopathy despite all efforts and treatments. Nicotine e-liquids are known to contain very dense substances, and it should be known that deliberate ingestion of these fluids can lead to nicotine poisoning, cardiac arrhythmias, and other life-threatening conditions (43).
A 27-year-old man was admitted to the emergency room after an EC had exploded in his mouth during use. He had recently replaced the battery of the EC with a new lithium ion one. He complained of foreign body sensation, throat pain, and difficulty swallowing. A CT scan of the neck revealed fractures of the superior cortex of the anterior arch at C1 as well as the foreign body image (44).

In this report from 2017, explosion of an EC resulted in high-pressure injection injury of the finger (45).

A previously healthy 18-year-old woman presented to hospital with dyspnoea, cough, and pleural pain after using an EC. She had started using an EC about 3 weeks earlier and then stopped using it 1–2 days before the onset of her symptoms. On admission, she had a respiratory rate of 32 breaths per minute and a pulse rate of 130 per minute. Her oxygen saturation was 84% on room air. CT angiography did not reveal an embolism. However, dependent opacities at both lung bases, interlobular septal thickening, and bilateral small to moderate pleural effusions were reported. She was intubated in the intensive care unit because of a deteriorating clinical status. The erythrocyte count was 900 and the leukocyte count was 340 (26% neutrophils, 13% lymphocytes, 14% monocytes, 25% mononuclear cells, and 22% eosinophils) in BAL fluid. No growth was found on bacterial or fungal culture. The diagnosis was hypersensitivity pneumonitis and acute respiratory distress syndrome secondary to EC exposure. The patient responded well to prednisolone (46).

A 33-year-old man with known diabetes and epilepsy was admitted to the emergency department with worsening dyspnoea and haemoptysis. About 2 weeks earlier, he had been diagnosed with community-acquired pneumonia and was treated with antibiotics but without complete resolution. The patient had been using ECs for the previous 2 months and had tried new flavours. A CT scan of the chest revealed areas of patchy consolidation and diffuse ground-glass opacities bilaterally. A BAL cell count revealed 30,000 erythrocytes and 800 leukocytes (42% neutrophils, 36% lymphocytes, 21% macrophages, and 1% eosinophils). Serological markers of inflammation were negative. A right wedge resection lung biopsy was performed; the diagnosis was bland pulmonary haemorrhage with no evidence of capillaritis or diffuse alveolar damage (47).
A young female vaper was admitted to hospital with cough, fever, night sweats, and breathlessness. Her biochemical and inflammatory marker levels were normal. High-resolution CT revealed diffuse ground-glass infiltrates with reticulation. Bronchoscopic findings were inconclusive, so the patient underwent a video-assisted thoracoscopic surgical biopsy and was diagnosed with lipoid pneumonia. The lipid source was suspected to be the plant-based glycerol in her EC (48). Most brands of EC contain glycerine, and other cases of lipoid pneumonia (30) and acute eosinophilic pneumonia (32) after inhalation of this substance have been reported (30,32).

Report 22
This report, published in 2018, included 14 patients with thermal and blast injuries as a result of explosion of ECs. The mean patient age was 28.6 ± 8.6 years. Fifty-seven percent of the patients had third-degree burns, 29% had deep second-degree burns, and 14% had superficial second-degree burns (3).

Report 23
A 40-year-old woman was admitted to hospital with a 1-month history of increased shortness of breath and sharp chest pain bilaterally. She had been a cigarette smoker until about 1 month earlier, at which time she had switched to ECs in an effort to quit smoking. CT revealed multifocal, diffuse, confluent ground-glass opacities in the lung lobes bilaterally. Bronchoscopy had been reported as normal. The results of bacterial and fungal cultures and viral serology were negative. Open lung biopsy was performed and the histopathological diagnosis was organising pneumonia (49).

Discussion
This review of the existing literature reveals that ECs are harmful to health or at least as harmful as tobacco. In 2006, the World Health Organisation declared that all forms of smoking are harmful to health and reported that the tobacco industry is "hiding" behind words such as "light" and "ultra-light" (50). Terminology such as "menthol," "non-nicotine," “electronic,” “vaping,” "harmless," and "less harmful" can be added today. The erroneous belief that ECs are less harmful to health than tobacco-containing cigarettes must be addressed with urgency. Given the conditions of the changing day, it is clear that the fight against the tobacco industry needs to be more stepped up.

The diversity of the cases reported in this review suggests that we are currently facing a problem of unknown magnitude. If we consider the problem only from the point of view of the lungs, lipoid pneumonia (30,48), subacute bronchiolitis (31), acute eosinophilic pneumonia (32), multiple reactive pulmonary nodules (37), hypersensitivity pneumonia (46), diffuse alveolar haemorrhage (47), and organizing pneumonia (49) are among the reported complications. All of these complications are attributable to the substances contained in ECs and against the inflammatory and irritative reactions of the lungs. It is possible that lipoid pneumonia is caused by the inhalation of glycerine. However, the effects of other substances on the lungs are not fully understood. Our lack of knowledge about
the substances or fragrances contained in EC liquids, the ability of EC devices to vaporise these liquids, and the frequency with which users inhale from the device creates difficulty when attempting to determine the effects of ECs. Our personal experience is that there are many people who switch from cigarettes to ECs but end up using both. The diversity of EC devices and liquids is rapidly increasing as a result of loopholes in legislation. Therefore, it is not possible to examine the mixtures in the liquids one by one. The risk of injury if a device explodes is another important issue. Hand/finger (35,45), dental (39), corneoscleral (26), mouth/tongue (29), leg (34), and facial (40,41) injuries as well as a C1/C2 fracture have been reported (44). Explosion of the device during use frequently occurs because of the battery.

The main issue with ECs is whether they have a benefit in terms of smoking cessation. In a recent review that addressed this question, it was concluded that ECs may help some smokers to quit or reduce smoking (51). Some of the publications in the literature should be evaluated carefully for bias (27). Another important issue is that there have been some studies comparing tobacco-containing cigarettes and ECs with some blood and lung function parameters. A review by Callahan-Lyon (18) found a degree of bias in studies concluding that ECs were less harmful to health. The studies cited in that review did not contain non-smoking controls, contained study populations of inadequate size, and did not investigate the consequences of short-term vs long-term exposure, so they were considered to be of poor quality (18).

However, there is an urgent need for well-designed, robust, evidence-based studies investigating the long-term effects of ECs, the individuals in whom they might be useful, and when and where they could be used. The variety of devices and e-liquids is rapidly increasing, making these devices attractive for many people but creating methodological difficulties for researchers. There is an urgent need for legislation and restriction regarding the sale of these devices in view of their increasing frequency of use in the younger age groups.

Conclusion

ECs are at least as harmful to health as conventional cigarettes and are particularly dangerous because of the risk of explosion. Complications that develop directly as a result of the substances contained in the devices and the adverse events resulting from explosion and burning of the device are being reported with increasing frequency. Use of ECs can also cause serious lung conditions, such as lipid pneumonia, acute eosinophilic pneumonia, hypersensitivity pneumonitis, organized pneumonia, bronchiolitis, diffuse alveolar haemorrhage, reactive pulmonary nodules, and respiratory failure.

Ethics Committee Approval: Per the policies of our institution, there is no requirement for ethics committee approval for review article.
Informed Consent: There is no requirement for informed consent for review article.

Conflict of interest: The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Legend of Figure

Figure-1: Electronic cigarette use among middle and high school students

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Table 1. Substances in e-cigarette aerosol and their effects^10

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Function of liquid</th>
<th>Health hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propylene glycol</td>
<td>The main component of the liquid to produce aerosols</td>
<td>• respiratory tract irritation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• the effect of long-term inhalation is unknown.</td>
</tr>
<tr>
<td>Glycerine</td>
<td>The main component of the liquid to produce aerosols</td>
<td>• the effect of long-term inhalation is unknown.</td>
</tr>
<tr>
<td>Tobacco</td>
<td>The component of the fluid</td>
<td>• dependency potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• cardiovascular diseases, Type-2 Diabetes, tumor growth</td>
</tr>
</tbody>
</table>

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### Table 2. Complications associated with electronic cigarettes

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Aroma Characteristics</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diacetyl</td>
<td>The aroma of many sweet liquids</td>
<td>• it is likely to affect lung development in unborn children</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• toxic effects</td>
</tr>
<tr>
<td>Benzaldehyde</td>
<td>Aroma (artificial bitter almond oil)</td>
<td>• respiratory tract irritation</td>
</tr>
<tr>
<td>Cinnamon aldehyde</td>
<td>Aroma (Cinnamon)</td>
<td>• suspected to cause bronchiolitis obliteration</td>
</tr>
<tr>
<td>Acrolein</td>
<td>Occurs when heating the liquid</td>
<td>• cytotoxic effect in cell culture</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>Occurs when heating the liquid</td>
<td>• possibly carcinogen (category 2B)</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Occurs when heating the liquid</td>
<td>• carcinogen (category 1)</td>
</tr>
<tr>
<td>Lead</td>
<td>Probably comes out of the wick / solder joints</td>
<td>• poisonous, • irritant</td>
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<tr>
<td>Chromium</td>
<td>Probably comes out of the wick / solder joints</td>
<td>• possibly carcinogen (category 2B)</td>
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<td>Nickel</td>
<td>Probably comes out of the wick / solder joints</td>
<td>• carcinogens when inhaled (category 1)</td>
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<tr>
<td>Tobacco specific nitrosamines</td>
<td>Rare pollution in some individual liquids</td>
<td>• carcinogen</td>
</tr>
<tr>
<td>Fine and fine particles (PM2.5, PM10)</td>
<td>Occurs during evaporation of liquid</td>
<td>• particulates are associated with respiratory problems, chronic respiratory and cardiovascular disease exacerbations, reduced lung function and premature death.</td>
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<tr>
<td></td>
<td></td>
<td>• The health effects of the particles in the e-cigarette aerosol are unknown.</td>
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Quoted from reference 10.
<table>
<thead>
<tr>
<th>Author</th>
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<tr>
<td>CBS NEWS</td>
<td>2012</td>
<td>Mouth and tongue injuries</td>
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<td>McCauley L.</td>
<td>2012</td>
<td>Lipoid pneumonia</td>
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<tr>
<td>Hureaux J.</td>
<td>2014</td>
<td>Subacute bronchiolitis</td>
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<td>Acute eosinophilic pneumonia</td>
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<td>Moore K.</td>
<td>2015</td>
<td>Pneumonia and bilateral pleural effusion</td>
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<td>Jablow LM.</td>
<td>2015</td>
<td>Leg burn and injury</td>
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<td>Maridet C.</td>
<td>2015</td>
<td>Nickel contact allergy</td>
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<td>Chen BC.</td>
<td>2015</td>
<td>Death following intentional e-liquid intake</td>
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<tr>
<td>Ring Madsen L.</td>
<td>2016</td>
<td>Multiple pulmonary nodules mimicking metastatic cancer</td>
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<tr>
<td>Shastry S.</td>
<td>2016</td>
<td>Shotgun-like superficial injury and contusion</td>
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<td>Rogér JM.</td>
<td>2016</td>
<td>Oral trauma and dental avulsion</td>
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<td>Paley GL.</td>
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<td>Corneoscleral rupture and ocular burn</td>
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<td>Archambeau BA.</td>
<td>2016</td>
<td>Complex facial fractures and pneumocephalus</td>
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<td>Vaught B.</td>
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<td>Facial trauma, fractures</td>
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<td>Brooks JK.</td>
<td>2017</td>
<td>Extensive intraoral injuries</td>
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<td>van der Meer DH.</td>
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<td>Fatal intoxication after ingestion of liquids</td>
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<td>Norii T.</td>
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<td>C1 and C2 fracture</td>
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<td>2017</td>
<td>High-pressure injection injury of the finger</td>
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<td>Hypersensitivity pneumonia and ARDS</td>
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<td>Agustin M.</td>
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<td>Diffuse alveolar Hemorrhage</td>
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<td>Viswam D.</td>
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<td>Respiratory failure and lipoid pneumonia</td>
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<td>Hickey S.</td>
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