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Exploring Electronic Cigarettes: Ingredients, Health Effects and Considerations for E-Cigarette Use.

Abstract

Electronic cigarettes, or e-cigarettes are becoming an increasingly popular nicotine delivery system, especially among adolescents and college aged students. They appeal to this population because they are new, are convenient to use, have appealing flavors, and are viewed as a cleaner, safer alternative to cigarettes. However, there are known ingredients in both the e-cigarette solution and vapors that have significant health effects and it is becoming an emerging public health issue that needs to be addressed. There is a gap in the knowledge about the potential harmful effects of e-cigarettes on both the part of the user and the healthcare providers who may need to counsel a user of e-cigarettes, since a lot of evidence is still emerging related to the health effects of e-cigarette use. To address this gap in knowledge, this paper summarizes some of the literature related to e-cigarette use, their health and safety effects that could be used to inform both users and healthcare providers, specifically nurses and nurse practitioners. There is still much to be learned about the long-term effects of e-cigarette use and what healthcare providers can do to minimize those effects.

Keywords: E-cigarettes, ENDS, vaping, e-cig, electronic cigarettes, smoking cessation

Introduction

With the recent decline in cigarette consumption by the public, there has been a dramatic increase in the use of alternate forms of nicotine such as electronic cigarettes (Cope, 2016). Electronic cigarettes are cigarette-like devices that consist of a battery, an atomizer, a cartridge, and a mouthpiece (Prochnow, 2017). Electronic cigarettes are often perceived as harmless, cleaner, and “cooler” than cigarettes. In the US population, lifetime use of electronic cigarettes among cigarette smokers increased from 10% in 2010 to 37% in 2013 (Das & Prochaska, 2017).

In particular, the use of electronic cigarettes has been steadily increasing among adolescents and young adults. The highest prevalence of e-cigarette use is among 18 to 24-year-olds (Adkison et al., 2013). This is associated with the ease of obtaining electronic cigarettes and the perception that using electronic cigarettes is healthier than traditional cigarettes. The tobacco industry targets young individuals with flavorings such as fruit, bubble gum, cinnamon, and piña

colada (Kamat & Van Dyke, 2017). There are currently about 500 different brands of e-cigarettes and nearly 8,000 flavors available for consumption (Bond, 2016). At present there is little regulation regarding e-cigarettes, but this is about to change.

On August 10, 2018, the U.S. Food and Drug Administration (FDA) will begin to federally regulate electronic cigarettes the same way that they regulate other tobacco products (Pirschel, 2016). The FDA regulations will assure that electronic cigarette manufacturers are only able to make claims if the FDA determines there is scientific evidence to do so (Cooper, Loukas, Harrell, & Perry, 2017). In addition, any electronic cigarette products that contain nicotine must have a warning statement on their label, stating that their product contains nicotine, which is an addictive chemical (U.S. Food and Drug Administration [FDA], 2017). New regulations regarding e-cigarettes may help users and healthcare providers more readily identify health risks.

However, the current knowledge base for some healthcare providers about these products is still limited. A survey administered by Al-Abed, Chung, Lin, and Ismail (2014) showed that nurse practitioners and nurses had the lowest level of comfort and confidence in providing e-cigarette information to patients as compared with physicians and respiratory therapists. Ridner, Keith, Walker, Hart, and Robertson (2017) showed that 19% of nurse practitioners surveyed viewed e-cigarettes as being as effective as nicotine replacement therapy (NRT). Current evidence states that there are more effective measures of smoking cessation interventions. In a study by Cheney, Gowin, and Wann (2015), several e-cigarette store owners stated that some of their customers had been referred by their healthcare providers to use e-cigarettes to quit smoking. In effect, the knowledge deficit of healthcare providers can serve as a barrier to providing education and guidance to patients and families about e-cigarette use.

Purpose

The purpose of this focused literature review is to reduce the gap in knowledge of healthcare providers regarding electronic cigarette use and to serve as a foundation for an educational program for nurses and nurse practitioners as part of an honors project. By increasing awareness and knowledge about the actual and potential adverse effects of electronic cigarette use, healthcare providers may be able to improve client outcomes regarding cessation of nicotine-based products, including e-cigarettes among young adults. According to Kamat and Van Dyke (2017), adolescence and early adulthood are characterized by risk-taking and novelty-seeking behaviors and strong emotions. Adolescents who smoke are at a higher risk of developing addictions than those who did not smoke during adolescence. Higher rates of e-cigarette use among youth have been associated with the general perception that these products are natural, harmless, or even beneficial. However, the literature shows that e-cigarettes still contain toxic chemicals and carcinogens similar to those in cigarettes, but at lower concentrations. Thus, education about e-cigarettes and their potential health effects is imperative.

Review of Literature

In order to address some of the gaps in knowledge that nurses and nurse practitioners, healthcare providers need to be specifically aware as to what an e-cigarette is, how it works, the ingredients and the related health effects. This review of literature will also discuss why the e-cigarette is so popular among young adults and college-aged students.

What is an Electronic Cigarette?

Electronic cigarettes are an example of an electronic nicotine delivery system (ENDS). The atomizer, charged by the battery, produces a vapor by heating the e-cigarette solution, sometimes up to 350°C (Cope, 2016). Users can change the voltage of their e-cigarettes and adjust the amount of vapor, flavor, and temperature. The electronic cigarette solution contains nicotine,

propylene glycol, glycerin, flavoring, and other chemicals (Das & Prochaska, 2017). Although not all e-cigarette products contain nicotine, when present, nicotine in these products is derived from tobacco (Prochnow, 2017). Nicotine concentrations differ, and there are wide variations in the solvents used and the flavorings in the e-cigarette solutions or “juice,” many of which are chosen to be attractive to younger users (Cope, 2016).

Why Are E-Cigarettes Popular In College Aged Students?

As stated before, the highest rates of e-cigarette use are currently found among adolescents and young adults. A study conducted in upstate New York reported that 71.6% of college-aged e-cigarette users used an e-cigarette “to try something new.” 72.7% of those who used e-cigarettes reported using them to quit smoking (Saddleson et al., 2016). Kong and colleagues found that common reasons for experimenting with e-cigarettes were curiosity (54.4%), appealing flavor (43.8%), and peer influences (31.6%) (Kong, Morean, Cavallo, Camenga, & Krishnan-Sarin, 2014). In a recent study by Lee, Lin, Seo, and Lohrmann (2017), approximately 40% of college students tried e-cigarettes in their lifetime.

College students are also more likely to experiment with e-cigarettes due to USB rechargeability; this feature fits easily in their life because they can charge the device using their laptops or cellphone chargers (Lee et al., 2017). Higher rates of e-cigarette use have also been linked to the general perception that these products are natural, harmless, or even beneficial. A study compared perceptions of college students about both cigarettes and e-cigarettes. The majority of respondents saw traditional cigarettes as extremely harmful (86%) and very addictive (86%), whereas almost half (47%) of respondents said that e-cigarettes pose no or little harm. Other studies also reported a low degree of perceived harm and addictiveness of e-cigarettes among young adults (Cooper et al., 2017).

Flavors such as fruit, candy, tobacco, and alcohol appeal to the youth. One study showed that young individuals perceived flavorings and bright colors of e-cigarette solutions as a healthy alternative and as less dangerous and less addictive than non-flavored products (Prochnow, 2017). The perception that a product is less harmful than another product has been shown to increase interest in trying that product (Saddleson et al., 2016).

E-cigarette Ingredients

The ingredients in e-cigarettes do have more harmful effects than what is perceived. E-cigarette solutions contain a variety of chemicals, including nicotine. See Table 1 for a summary of key ingredients that are present in e-cigarette solutions and potential side effects that are known.

Flavoring	Cinnamon: cinnamaldehyde and 2-methoxycinnamaldehyde	<ul style="list-style-type: none"> ● Toxic to body cells ● Stimulates stress and weakens respiratory immune defenses against bacterial and viral infections ● Effects are less than those associated with cigarette smoking (Husari et al., 2015)
	Butter: diacetyl (2,3-butanedione)	<ul style="list-style-type: none"> ● Approved for use in food products as it is safe when ingested in the gastrointestinal system ● When inhaled, is associated with bronchiolitis obliterans (an inflammatory lung disease) and a decline in respiratory function (Bond, 2016; Farsalinos et al., 2013; Kim & Baum, 2015) ● 75% of solutions reviewed by Farsalinos et al. (2013) contained diacetyl, even in products claimed to be free of it
	Fruit flavors: benzaldehyde	<ul style="list-style-type: none"> ● Causes inflammation and irritation in respiratory airways ● Cherry-flavored solutions: Significantly high levels detected ● Tobacco- and coffee-flavored solutions: High levels detected ● Amounts of benzaldehyde inhaled with 30 puffs from e-cigarettes often greater than inhaled from cigarettes (Kosmider et al., 2016)
Vapor	Metals	<ul style="list-style-type: none"> ● Toxic to humans, no established safe levels of inhalation ● Chromium: Present in e-cigarette vapor, but absent in cigarette smoke ● Lead: Can cause severe neurological damage and hematologic dysfunction ● Cadmium: Causes kidney, liver, bone, and respiratory tract pathology and can cause organ failure, high blood pressure, anemia, fractures, and osteoporosis (Smith, Brar, Srinivasan, Enja, & Lippmann, 2016)
	Ultrafine particles	<ul style="list-style-type: none"> ● Can worsen respiratory conditions (bronchitis, asthma) ● Can cause impairment in liver, kidney, heart, and brain function ● Constrict arteries around the body (Zborovskaya, 2017)

Volatile organic compounds (VOC)	<ul style="list-style-type: none"> • Can cause headaches, bronchial irritation, nausea, damage to liver and kidneys, and cancer • E-cigarette vapor contains fewer VOCs compared to cigarette smoke (Zborovskaya, 2017)
Formaldehyde	<ul style="list-style-type: none"> • Found at higher levels in e-cigarette vapor than cigarette smoke (Jensen et al., 2015) • Associated with neck cancer and cancers of the lymphatic system • Can cause pulmonary edema, dyspnea, bronchitis, arrhythmia, and tachycardia, and allergies (Zborovskaya, 2017)
Acrolein	<ul style="list-style-type: none"> • Associated with increased risk for atherosclerosis due to platelet activation • Suppresses circulating angiogenic cell levels, increasing risk for cardiovascular disease (DeJarnett et al., 2014)
Tobacco-specific nitrosamines	<ul style="list-style-type: none"> • Potent lung carcinogens that have a great potential to cause lung cancer (Shahab et al., 2017)

Table 1. A list of chemicals present in e-cigarette solutions and vapor.

The main ingredient of e-cigarettes is nicotine, which leads to the release of hormones that increase heart rate and cardiac contractility. Nicotine also causes blood vessels to constrict, thereby increasing blood pressure (Prochnow, 2017). According to Mello, Bigman, Sanders-Jackson, and Tan (2015), nicotine is often found at levels significantly higher than those listed on the labels of e-cigarettes. A study by Davis, Dang, Kim, and Talbot (2014) evaluated nicotine concentrations in 71 e-cigarette solutions, which revealed that 65% of e-cigarette products had nicotine concentrations deviating by more than 10% from what the labels had listed.

Propylene glycol is the solvent for electronic cigarettes that is used to make the solution, or “e-juice.” When it is heated, this chemical breaks down into the carcinogens formaldehyde and acetone. At least one e-cig brand reviewed by Kamat and Van Dyke was shown to release metallic particles that have the potential to cause respiratory disease (Kamat & Van Dyke, 2017).

Adverse Health Effects of E-cigarettes

Both cigarette and e-cigarette smoking induce similar increases in heart rate and nicotine concentration in blood vessels (Jamshed, 2015). Kim and Baum (2015) reported that the levels of cotinine, a metabolite of nicotine, in the blood were similar in e-cigarette and traditional cigarette users. This represents that e-cigarette users can experience adverse effects of nicotine to a similar magnitude as cigarette smokers. Nicotine has profound effects on the circulatory system of the user. Nicotine increases the formation of atheroma, or small fatty lumps inside blood vessels, causes inflammation and modifies smooth muscle cells (Santanam et al., 2012). In individuals with diabetes, it can cause insulin resistance (Prochnow, 2017). In addition to the effects of nicotine on the cardiovascular system and endocrine system, nicotine can have more severe effects on the nervous system (Cope, 2016). Nicotine is detrimental to the developing fetus and brain development in teenagers and young adults (Bond, 2016). Nicotine may increase the risk of addiction to other substances by causing changes in the adolescent brain. It is linked to learning, memory, attention, and behavior issues in this age group (Prochnow, 2017).

Adverse effects of e-cigarette use include mouth and throat irritation, aching jaws, nausea, passing of gas, vertigo, headache, excessive sweating, and palpitations. E-cigarette use can also cause dry cough, irritation of the respiratory tract, and increased susceptibility to respiratory viral infections. Severe effects also include low blood pressure, slow heart rate, difficulty breathing, and eventually coma and respiratory failure (Kim & Baum, 2015). E-cigarette use increases the lifetime risk of cancer by as much as 15 times, compared to the risk from prolonged cigarette smoking (Zborovskaya, 2017).

Analysis of e-cigarette vapor by Higham et al. (2016) showed that the e-cigarette vapor causes activation of white blood cells, a characteristic of chronic obstructive pulmonary disease (COPD). Higham et al. (2016) raised concerns about the safety of e-cigarettes as they believed

that e-cigarettes contain chemicals that white blood cells saw as potentially dangerous to the human body. Sufficient research about the effects of repeated exposure on white blood cell activation does not currently exist, but the acute effects reported in the study were similar to those caused by cigarette smoke, suggesting that chronic exposure to e-cigarettes may lead to similar chronic inflammatory changes seen in cigarette smokers (Higham et al., 2016).

While there are known health effects in individuals who use e-cigarettes, secondhand exposure health effects also need to be studied. Although secondhand vapor poses lower risks to public health, it still affects the individuals inhaling the vapor. E-cigarettes can generate indoor air pollution as they do not simply emit water vapor. Secondhand vapor exposes non-users to nicotine and chemicals present in the vapor (Prochnow, 2017). The levels of metals, such as nickel and chromium, in secondhand vapor are higher than background air (Cope, 2016; Wilson, Hoek, Thomson, & Edwards, 2017). Nicotine in secondhand vapor has been found to be 10 to 115 times higher than background air, acetaldehyde between two to eight times higher, and formaldehyde about 20% higher (Wilson et al., 2017). These findings suggest that exposure to e-cigarette vapor can affect the health of individuals inhaling the vapor, causing adverse effects such as nausea, headache, and excessive sweating (Kim & Baum, 2015). The common misperception is that the vapor only contains water.

Safety and Public Health Considerations Related To E-Cigarette Use

In addition to the concerns about the health effects of e-cigarette use, there are also safety and public health considerations that need to be brought to the attention of users and healthcare providers. Due to the lack of regulations on e-cigarette manufacturing, there have been documented cases of fires and explosions with e-cigarette use, mostly due to malfunctioning lithium-ion batteries (Cope, 2016; Smith et al., 2016). Although rare, these incidents have resulted

in extensive losses of property and minor to severe injuries for users, including burns to the legs, hands, tongue, mouth, fingers, and throat, shattered teeth, and facial fractures and concussions (Prochnow, 2017). E-cigarettes may ultimately be shown to be less harmful than regular cigarettes, however there is concern about the significant variations in the concentrations of the ingredients in e-cigarette solutions (Pepper, McRee, & Gilkey, 2014). Even though the levels of toxic chemicals in e-cigarette solutions are much lower and less dangerous than those found in cigarettes, the effects of long-term exposure to these chemicals are unknown and they may still pose a significant risk when inhaled over long periods (Antolin & Barkley, 2015; Cope, 2016; Kamat & Van Dyke, 2017).

E-cigarettes are generally considered by smokers to be a safer way of consuming nicotine than cigarettes due to lower levels of harmful chemicals present in the e-cigarette vapor. Although e-cigarettes have been proposed by their manufacturers and supporters as an effective aid to quit smoking, a recent review concluded that e-cigarette users may be 28% less likely to quit smoking than non-users, which could become problematic for their health, considering the dangerous chemicals found in e-cigarettes (Kalkhoran & Glantz, 2016). Furthermore, nicotine levels in e-cigarette solutions are too irregular to be considered safe (Jamshed, 2015). Therefore, e-cigarette users may unknowingly be exposed to the harmful effects of nicotine due to the irregular nicotine concentrations, thus leading to a higher risk of nicotine toxicity.

Public health concerns also need to be considered, including e-cigarette appeal to the youth, potential to make social norms about smoking behaviors more acceptable, nicotine toxicity, and secondhand exposure to vapor (Antolin & Barkley, 2015). Kamat and Van Dyke (2017) argue that adolescents who smoke are at a higher risk of developing addictions than those who did not smoke during adolescence. E-cigarette use among youth may lead to use of cigarettes, alcohol or

illegal drugs. Cross-sectional studies of adolescent e-cigarette users in the United States show that up to 55% of these individuals consume multiple tobacco products, and even “non-smokers” who explicitly use e-cigarettes have an over 8-fold increased risk of progression to cigarette use (Kamat & Van Dyke, 2017).

Experimental e-cigarette use may encourage young non-smokers to start using e-cigarettes on a regular basis. It may also foster nicotine dependence and serve as a gateway to smoking cigarettes. This may have the potential to renormalize smoking behaviors and undermine efforts to cast these behaviors as undesirable habits. Thus, restrictions on e-cigarette use could make e-cigarette use seem risky or inconvenient and reduce appeal to users (Mello et al., 2015).

More and more individuals are switching from smoking cigarettes to using e-cigarettes because of advertising and anecdotal evidence as a replacement for cigarettes or as a smoking cessation tool (Cope, 2016). Some individuals use e-cigarettes as a means to quit smoking, but very few who do so achieve abstinence. They frequently end up utilizing both, which increases their health risks as they are exposing themselves to the dangers of two products instead of one (Smith et al., 2016). E-cigarettes are likely to be beneficial only if complete cessation of cigarette smoking is achieved. Therefore, dual users of cigarettes and e-cigarettes should be encouraged to stop using cigarettes. Most importantly, although e-cigarettes and nicotine replacement therapy are linked to reductions in carcinogens and toxins compared with cigarettes, use of these products do not eliminate exposure. Thus, full cessation of all products that contain nicotine is the best option to prevent harm (Shahab et al., 2017).

Healthcare Provider’s Role

Healthcare providers have an important role in caring for clients who use or may potentially consider e-cigarette use, including knowing how to advise and counsel about use.—Healthcare providers must educate their clients and advocate for them by recommending cessation of e-cigarette use. Since nurses are usually the first to meet with clients in a healthcare setting, they have an important role in assessing their clients’ e-cigarette use. If their clients indicate that they are using tobacco products, nurses must treat them with respect and provide nonjudgmental care. In addition, providers need to be knowledgeable about vaping culture and be prepared to provide appropriate resources for clients interested in smoking cessation. Cope (2016) states that nurses who perform tobacco use screening and brief interventions can have a significant impact on their clients’ smoking cessation success.

Healthcare providers should utilize the ‘5A’ technique for counseling clients for cessation. The ‘5A’ technique consists of Ask, Advise, Assess, Assist, and Arrange (Prochnow, 2017).

1. Ask: Asking about all tobacco use, including e-cigarettes.
2. Advise: Advising e-cigarette users to quit in a clear and personalized manner.
3. Assess: Assessing the client’s willingness to stop use, identifying motives for using e-cigarettes, and exploring their knowledge of e-cigarettes.
4. Assist: Providing information on FDA-approved tobacco cessation products, identifying barriers, resources, and support system, and supporting client’s efforts using non-shaming language.
5. Arrange: Arranging follow-up, providing support, addressing challenges, and counseling clients.

For example, a client who is a cigarette smoker and asks about e-cigarettes is potentially showing a willingness for smoking cessation. Therefore, healthcare providers must take advantage

of this opportunity to help the client quit, using nicotine replacement therapy (NRT) and medications (Zborovskaya, 2017). Furthermore, if a client expresses a desire to use e-cigarettes to quit smoking, healthcare providers should advise the client about possible dangers, explain that e-cigarettes should only be used for a limited time, and recommend that a quit date should be made and adhered to. Most importantly, providers should recommend NRT as the cessation tool of choice with proven efficacy for smoking cessation over e-cigarettes as there are unknown long-term effects of e-cigarettes (Ridner et al., 2017). In addition, as more research findings become available, healthcare providers need to educate themselves as well as clients about the potential impact of e-cigarettes (Cope, 2016).

Conclusion

Healthcare providers such as nurses and nurse practitioners need to be aware of the health risks associated with electronic cigarettes. There is still a developing knowledge base on e-cigarettes and the long-term health effects. Despite the lower concentrations of toxic chemicals and carcinogens, electronic cigarettes still contain chemicals that may cause substantial harm to user's health. Although long-term health effects of e-cigarette use are currently unknown, adverse effects of e-cigarette use on the user's cardiovascular, neurological, and endocrine systems are known. Given the high number of college-aged individuals believing that e-cigarettes pose no or little harm, it is important that healthcare providers educate these individuals. Healthcare providers can attend research conferences and review the literature in order to stay current with the growing body of knowledge regarding electronic cigarettes. By keeping current with the literature and knowledge related to e-cigarettes, nurses and nurse practitioners should become more comfortable in counseling clients regarding tobacco use cessation, including cessation of e-cigarettes. More

research is needed to assess the health implications of e-cigarette use and secondhand exposure to e-cigarette emissions.

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