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## An Evidence-Based Approach to Understanding and Treating Electronic Cigarette Use in the Adolescent Population

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An Evidence-Based Approach to Understanding and Treating  
Electronic Cigarette Use in the Adolescent Population

Adelaide Laurel Amini

A project submitted to the faculty of  
Brigham Young University  
in partial fulfillment of the requirements for the degree of  
Master of Science

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## ABSTRACT

### An Evidence-Based Approach to Understanding and Treating Electronic Cigarette Use in the Adolescent Population

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Electronic cigarette (e-cigarette) use is popular among adolescents and leads to high levels of nicotine exposure in this population. E-cigarette use by teenagers can lead to development of nicotine addiction, chronic lung disorders, and lifelong incidence of depression, anxiety, and attention-deficit disorder. Thus, it is vital that nurse practitioners understand electronic cigarette devices and their effects on adolescent health, as well as treatment guidelines regarding nicotine dependence specific to e-cigarettes. An educational module detailing the history of e-cigarettes, adolescent vulnerabilities, health effects of vaping, and treatment options, was created and distributed among a sample of 12 nurse practitioners. The purpose of the module is to increase nurse practitioners' understanding of teenage e-cigarette use. Understanding was assessed before and after viewing the module, using a paired t-test. The results showed a significant increase in participants' knowledge of e-cigarettes after completing the module,  $t(11)=5.4$ ,  $p=0.001$ . Of the 12 participants, 83% indicated that their general understanding of e-cigarette use in the adolescent population improved and 83% indicated that their understanding of available treatment options for adolescent nicotine cessation improved. This module will become available to nurse practitioners nationwide, via the American Association of Nurse Practitioners online continuing education site, in order to further help healthcare providers to gain a better understanding of e-cigarette use in the adolescent population.

Keywords: electronic cigarette, e-cigarette, vaping, teenage, adolescent

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An Evidence-Based Approach to Understanding and Treating  
Electronic Cigarette Use in the Adolescent Population

Nicotine exposure among America's youth has risen sharply over the past decade despite the declining rates of youth who use cigarettes (Cullen et al., 2018). This dramatic increase in adolescent nicotine use occurred as a result of the proliferation of electronic nicotine delivery devices, called electronic cigarettes or e-cigarettes. More commonly referred to as *vaping*, this new trend of e-cigarette use may soon result in a complete reversal of five decades of progress in the reduction of teenage tobacco use. The surge in rates of vaping among adolescents caught national attention in 2014 when e-cigarettes surpassed conventional cigarettes as the most commonly used tobacco product among teenagers (U.S. Department of Health and Human Services, 2016). Over the past five years, the number of high schoolers who use e-cigarettes has more than doubled from 13.4% in 2014 to over 27% in 2019 (Cullen et al., 2018; Cullen et al., 2019). Nurse practitioners who treat patients between the ages of 14 and 18 should understand that at least one in four of their patients is likely involved in some degree of e-cigarette use. Thus, it is imperative to understand e-cigarette devices, their effects on an adolescent's health, and treatment of patients who present with nicotine dependence specific to e-cigarettes.

E-cigarettes come in various forms, but most have a basic anatomy of a battery, an atomizer, a liquid cartridge, and a mouthpiece. When the user inhales, the battery of the e-cigarette heats the atomizer, which contains a metal coil. The coil then heats the liquid until it is hot enough to be aerosolized into a breathable form. Many e-liquids contain high concentrations of nicotine, and all e-liquids contain ingredients that are harmful to the lungs and other body systems when inhaled (U.S. Department of Health and Human Services, 2016).

Adolescents are particularly vulnerable to e-cigarette use for several reasons. Many are drawn to the variety of e-liquid flavors and can acquire the devices easily through the internet or from friends. Teens can use these devices discreetly, even at home or school, because many e-cigarette models do not look or smell like conventional cigarettes. Other vulnerabilities include low cost, peer pressure, targeted advertising by tobacco companies, misguided beliefs about health effects, social media influence, and a lack of comprehensive U.S. Food and Drug Administration (FDA) regulation. According to the U.S. Department of Health and Human Services (2016), e-cigarettes are most widely used by teenagers and young adults aged 14-24, even though these devices were originally designed as a smoking cessation aide for adults with tobacco use disorders.

The drastic rise in adolescent e-cigarette use particularly concerns healthcare providers because longitudinal studies have not been completed detailing the long-term health effects of vaping on brain, heart, and lung function. However, a recent study completed by Yuan et al. (2015) showed that inhaling high amounts of nicotine leads to significant cognitive impairment in adolescents, including increased rates of depression, anxiety, impulsivity, and reduced attention span.

Nurse practitioners must understand the nature of adolescent e-cigarette use to provide patients and their parents with effective prevention and cessation strategies. In fact, pediatric providers who are familiar with e-cigarette use in the adolescent population, and appropriate interventional strategies, will address vaping with their patients more frequently, leading to lower rates of initiation (Pepper, Gilkey, & Brewer, 2015).

One strategy for providing this timely information to practitioners is through the use of internet-based, electronic learning modules. Online training modules are a form of e-learning

that has been shown to be an effective educational tool (Mousazadeh et al., 2016). Thus, the purpose of this project is to provide a 60-minute online module detailing the existing guidelines for the prevention and treatment of adolescents involved in e-cigarette use. The information contained in this module will describe the current status of vaping in the adolescent population, highlight the specific vulnerabilities and health implications unique to youth, and provide evidence-based information regarding prevention and intervention strategies specifically focused on young e-cigarette users. The module is designed for Nurse Practitioners who work with adolescents. The module will be reviewed and tested by a minimum of twelve nurse practitioner experts. The experts will complete a survey about e-cigarette use in the teenage population before and after viewing the module.

## **Literature Review**

### **Background**

In 2003, a pharmacist named Hon Lik invented the first commercially available e-cigarette in Beijing, China (National Academies of Sciences, Engineering, and Medicine et al., 2018). The original purpose of the e-cigarette was to function as an alternative to traditional tobacco cessation products. Since entering the United States market in 2006, e-cigarettes have become popular among all age groups, but especially middle and high school students. For example, in 2015, only 3.5% of U.S. adults admitted to e-cigarette use compared with 5.5% of middle schoolers and 15.5% of high school students (Jamal et al., 2017; U.S. Department of Health and Human Services, 2016). E-cigarettes have been the most popular tobacco product used by teens since 2014, and the reported number of teens experimenting with use continues to rise yearly. In 2018, 3.6 million high schoolers reported current use of e-cigarettes, leading the Surgeon General to declare it an epidemic for American adolescents (Cullen et al., 2018).



The first type of e-cigarettes to be sold in the U.S. were “cig-a-likes” built to look and feel like a conventional cigarette but free of many of the traditional toxins and carcinogens found in cigarette smoke. These first-generation e-cigarettes are composed of a battery, an atomizer, a heating coil, a cartridge to hold liquid, and a mouthpiece. When a user inhales or manually presses a button, the battery powers the heating coil, which, combined with the atomizer, heats the liquid inside the cartridge to a high temperature, where it is then aerosolized and can be inhaled (Kaisar et al., 2016; Offermann, 2015).

Second-generation e-cigarettes, or vape pens, are similar to first-generation models in anatomy but have a few different features, including a clear chamber that can hold more liquid and a longer, narrower body, resembling a pen. Vape pens also allow the user to customize the power, frequency, and length of puffs. Third generation e-cigarettes, personalized vaporizers, or MODs differ greatly from the previous models as they are quite a bit larger and usually rectangular shaped. These devices have complex designs that allow users to modify components including wattage, voltage, and temperature (Rigotti & Kalkhoran, 2019).

In 2015, a new model of electronic nicotine delivery system (ENDS) was developed and introduced to the market called a “pod mod.” The first company to market these products was JUUL laboratories, but many other brands of pod mods have been developed since 2015. JUUL products were originally designed to look small and thin like a USB flash drive. Because of their inconspicuous appearance and different flavor options, these types of e-cigarettes became very popular among youth users, attributing greatly to the drastic increase of high school student e-cigarette use.

JUUL products are very different from traditional ENDS devices, both in shape and type of nicotine used. It is important to note that the e-liquid used in JUUL products always contains

nicotine. JUUL cartridges, called JUUL pods, contain nicotine salts derived from tobacco leaves rather than the freebase nicotine contained in typical e-liquid formulations, allowing the user to obtain a higher amount of nicotine per puff than most ENDS products (Willett et al., 2018). One 5% nicotine by weight (NBW) pod is akin to 200 puffs on a conventional cigarette and yields 59mg of nicotine per milliliter, which is as much nicotine as is contained in an entire pack of cigarettes (United States Food and Drug Administration, 2018).

The liquids used in e-cigarettes (called e-liquids, vape juice, or smoke juice) are composed of four main ingredients: water, flavoring, nicotine, and humectants. The humectants, usually substances like propylene glycol and glycerin, liquefy the other ingredients, allowing the e-liquid to transform into an aerosol when heated to a specific temperature (National Academies of Sciences, Engineering, and Medicine et al., 2018). Although some e-liquids do not contain nicotine, 99% include it in some amount (Marynak et al., 2017). E-liquids are commonly sold by nicotine concentration: zero (0mg/ml of nicotine), low (6-12mg/ml), medium (18mg/ml) and high (24mg/ml) (Kaisar et al., 2016). Many teens and adults report vaping with a liquid that contains 0mg/ml of nicotine according to the label. However, there are blatant inconsistencies with measured nicotine concentrations and their labeled amounts (Cheng, 2014; Hyman & Brown, 2017; Kaisar et al., 2016; National Academies of Sciences, Engineering, and Medicine et al., 2018; Rigotti & Kalkhoran, 2019). One study found between 5.7mg/ml to 23.9mg/ml of nicotine in multiple flavor samples from various companies that were all labeled as 0mg of nicotine (Raymond et al., 2018), and similar inconsistencies have been reported in other studies.

### **Adolescent Vulnerabilities with E-cigarettes**

Recent studies have highlighted many vulnerabilities specific to the adolescent population. To teenagers, one of the most attractive features of vaping is the multitude of

flavors. Some of the most popular flavors include strawberry watermelon, blue raspberry, and pink lemonade, but flavors can be as diverse as crème brûlée, nacho cheese, and dill pickle. In a Texas study of over 15,000 e-cigarette users, 98% of teens reported that the first e-liquid they tried was flavored to taste like “something other than tobacco.” Most adult e-cigarette users, however, reported that they prefer flavors similar to conventional cigarettes (Harrell et al., 2016). Adolescents often do not understand that fruity flavors have just as much nicotine and toxic components as tobacco or menthol-flavored liquids.

With approximately 15,000 flavors of e-liquid available for purchase, it is not surprising that one frequently cited reason that teens try vaping is that they are curious (Walley et al., 2019). In fact, 57.1% of students cited curiosity as a major reason they began vaping (Bold et al., 2016; Margolis et al., 2016). In a 2018 study, 25% of youth that had never before smoked a tobacco product reported that they were curious about e-cigarettes and open to trying them (Margolis et al., 2018). The internet is a pervasive source of promotional information regarding e-cigarette use. For example, people who actively vape can influence others by posting positive stories about their e-cigarette use and adding pictures or videos to social media platforms. Research has established a connection between viewing positive vaping themes on social media and subsequent e-cigarette initiation and use (Pokhrel et al., 2018). Other teens are attracted to using e-cigarettes for sports like cloud chasing, where participants use the smoke generated from the e-cigarette to make shapes and do tricks. In a study of 1,700 adolescents who use vaping devices, 74% reported watching vape tricks online, and 77.8% reported trying to mimic these tricks at home (Pepper et al., 2017).

Peer influence, both through social media and with friends at school, is another significant reason for youth e-cigarette initiation and continued use (Alberta Health Services,

2014; Cavallo et al., 2019; Hwang & Park, 2016; Pokhrel et al., 2018). Bold et al. (2016) found that 32.6% of teens stated that a major reason they began vaping was due to peer influence.

Adolescents have also cited that they are attracted to the ability to hide or disguise certain vaping devices such as the original JUUL device, which can be easily concealed from parents and teachers because of its unassuming appearance. Ramamurthi et al. (2018) searched YouTube for videos related to adolescents' methods for concealing e-cigarette usage, also known as "stealth vaping," and found 18,200 videos detailing how to vape in areas such as school and home without being caught. Specific products have been designed with discretion in mind such as low vapor visibility and low odor e-liquids. Some vaping devices are modeled to look strikingly similar to typical belongings such as coffee mugs, ballpoint pens, cell phones, key fobs, inhalers, boxes of Tic-tac's, and hoodie drawstrings (Ramamurthi et al., 2018).

Furthermore, teens have easy access to e-cigarette products using the internet. One study tested ease of acquisition by observing adolescent subjects attempt to purchase e-cigarettes from various online vendors. Of these 98 vendors, only five invoked a firm age restriction, resulting in a youth purchase rate of 93.7% (Williams, Derrick, & Ribisl, 2015). Since the FDA ruling in 2016, large companies have been forced to enforce age restrictions with internet sales. However, few of these restrictions exist on smaller retailer sites, allowing for relatively easy purchasing by minors (Chadi, Hadland, & Harris, 2019). Adolescents can also acquire e-cigarettes from friends, family members, or young adult contacts who buy e-cigarettes in bulk and sell them to minors for a profit. Of 3,614 high schoolers in a 2015 study, nearly half said they acquired their e-cigarettes from a friend (Krishnan-Sarin et al., 2015).

Low cost is another factor in teenage e-cigarette use. When compared with traditional cigarettes, e-cigarettes are much cheaper to use in the long run despite the moderately high start-

up cost. For example, a JUUL starter pack that includes the reusable device and four pods costs around \$50, and the subsequent four-packs cost \$16.99 each (Marcellin, 2019). One JUUL pod yields about 200 puffs, which, according to JUUL's website, is akin to a 20 pack of cigarettes, which retails between \$5-10/pack.

### **Health Implications of E-cigarette use in Adolescents**

An additional risk factor for youth e-cigarette use is the classic behavioral changes associated with adolescence that include increased risk-taking behavior (Yuan et al., 2015). These patterns of impulsive and risky behaviors can be partially attributed to the fact that the adolescent brain is actively maturing, creating additional synapses in the pathways responsible for cognitive development and emotion regulation. The human brain has reached its optimal mass by the age of 11 for girls and 14 for boys but continues development until the mid-30s (England et al., 2017). However, not all brain lobes mature at the same rate. According to Yuan, Cross, Loughlin & Leslie (2015), the emotional regions of the brain tend to mature more quickly than the decision-making and impulse control systems, leading to more emotionally based decisions associated with thrill-seeking behaviors. The limbic system, which specifically controls cognition, emotion, and the drug reward pathway, is actively maturing during adolescence. Conversely, the pre-frontal cortex, responsible for planning, processing information, and impulse control, does not fully mature until well into the second decade of life (England et al., 2017).

An adolescent's brain is in a critical stage of development and has much greater plasticity than an adult's brain because it is actively creating new synapses based on input from current life experiences. The brain uses these unique experiences to drive developmental pathways, especially regarding dopamine, the neurotransmitter primarily involved in feelings of pleasure

and reward in the brain. Dopamine is the main neurotransmitter involved in nicotine addiction. After nicotine is absorbed and enters the bloodstream, it exerts its effects on the brain using nicotinic acetylcholine receptors. The receptors accept the nicotine and initiate dopamine neurotransmitter release. Dopamine release also affects other neurotransmitters, increasing glutamate, and decreasing GABA, which both indirectly raise dopamine levels (U.S. Department of Health and Human Services, 2014).

Administering a drug like nicotine to a developing brain can manually rewire brain processes to adapt to the unnaturally high levels of dopamine that cause addiction and the low dopamine levels that remain after nicotine concentrations have tapered off, causing withdrawal. The normalization of the sharp contrasts between high and low levels of dopamine can cause a lifelong dopamine imbalance in the brain, potentiating or even causing depression, anxiety, attention deficit disorders, and impulsivity when these co-morbidities may not have developed had the brain never been exposed to nicotine. Furthermore, the ventral tegmental area in the adolescent brain, responsible for the reward system and addiction potential, is more sensitive to nicotine addiction than the adult brain. As a result, those who start vaping as teenagers are more likely to become lifetime smokers and have a harder time reversing the addiction than those who start as adults. England et al. (2017) states that since adults are past this critical developmental stage, fully matured adult brains do not have as much affinity to nicotine and are therefore less susceptible to addiction than adolescent brains.

In a study by Yuan, Cross, Loughlin & Leslie (2015), rats were used to model the difference between adolescent and adult nicotine-induced behavioral characteristics. Adolescent, but not adult, aged rats were shown to have increased impulsivity, anxiety, depression, and fear when chronically exposed to nicotine, as well as decreased cognitive abilities and attention span.

Another study showed that adolescent aged rodents exposed to consistent amounts of cigarette smoke demonstrated cognitive impairments that included reduced working memory, spatial memory, and auditory processing, as well as weakened executive planning irrespective of the last exposure (England et al., 2017).

Natural, non-drug reward pathways are also compromised in teenagers who use nicotine regularly, leading to significant struggles with cessation and an affinity for alternate drugs such as conventional cigarettes, marijuana, cocaine, methamphetamine, and alcohol (Curran et al., 2018; U.S. Department of Health and Human Services, 2016). One study cited that a third of adolescents who vape have also reported using an e-cigarette to smoke marijuana (Chadi et al., 2019). Additionally, various studies have concluded that e-cigarette use does lead to the use of combustible cigarettes (King et al., 2015; Pènzés et al., 2018; Primack et al., 2015; Rigotti & Kalkhoran, 2019; Walley et al., 2019).

### ***Nicotine Dependent Health Effects of Vaping***

Historically, nicotine has been classified as a substance that is addictive but does not adversely affect other organ systems, but this theory has since been proven false. Inhaled nicotine is rapidly absorbed and has sympathomimetic effects on the human body, causing increased heart rate and blood pressure and promoting systemic vasoconstriction, which can cause endothelial damage. Inflammation in the vascular tissue results in atherosclerotic plaque formation and platelet aggregation, the combination of which can produce a myocardial infarction or cerebrovascular accident. Nicotine use can also contribute to cardiac remodeling, leading to an increased risk of heart failure and sudden cardiac death. Frequent use of nicotine is associated with the development of hypertension, diabetes mellitus, dyslipidemia, and thrombogenesis (Benowitz & Burbank, 2016). Furthermore, it is hypothesized that nicotine can

affect the blood-brain barrier of the brain, thus increasing the risk of developing various neurodegenerative diseases in the future. Nicotine is also known to decrease systemic immune responses and increase systemic inflammation, leading to delayed wound healing, especially in areas of the mouth and gums where burns from vaping are common (Lei et al., 2017).

E-cigarettes can potentially deliver a much higher dose of nicotine into the bloodstream than a combustible cigarette. An average combustible cigarette contains between 10 and 15 milligrams of nicotine yet will only deliver about one milligram into the bloodstream (Bhatnagar et al., 2014). In contrast, an e-cigarette can deliver between a third to a fourth of its nicotine concentration into the systemic circulation, meaning that an e-liquid with a 24mg/ml concentration will deliver between six and eight milligrams of nicotine per milliliter of e-liquid into the systemic circulation when inhaled (Kaisar et al., 2016).

Lastly, multiple studies have demonstrated that adolescents who vape experience e-cigarette specific withdrawal symptoms, including difficulty concentrating, irritability, nervousness, restlessness or anxiety, and a strong urge to vape (Case et al., 2018; Pbert et al., 2015). Other withdrawal symptoms may include headaches, sleeping difficulty, and increased appetite (Chadi et al., 2019).

### ***Non-Nicotine Dependent Health Effects of Vaping***

E-cigarettes possess multiple health risks independent of the harms of nicotine. Although manufacturers have recently been forced to display nicotine-warning signs on the front of e-cigarette and e-liquid packaging, detailed ingredient lists are rarely included. Many of the chemicals contained in e-liquids are harmful when inhaled. The solvents propylene glycol and glycerol contained in most e-liquids have been labeled “GRAS” by the FDA but have only been approved for oral consumption in specific amounts and not for inhalation (Kaisar et al., 2016).



The flavorings in e-liquids are also far from benign. A 2015 study found that over three-fourths of 159 different sweet or creamy tasting e-liquids contained the flavoring chemicals diacetyl or acetyl propionyl, which have been known to cause a fixed obstructive lung disease called bronchiolitis obliterans when inhaled (Center for Disease Control and Prevention, 2002; Marcellin, 2019; National Academies of Sciences, Engineering, and Medicine et al., 2018). Bronchiolitis obliterans involves inflammation of the bronchioles, which can lead to scarring and respiratory compromise. This disease was nicknamed “popcorn lung” in the year 2000 after several employees in a microwave popcorn factory contracted a severe respiratory illness from inhaling the butter flavor fumes. Other studies have found that exposure to these chemicals can also cause asthma, bronchitis, and pulmonary fibrosis (Marcellin, 2019).

As of February 2020, there have been 2,807 cases of e-cigarette or vaping associated lung injuries (EVALI) and 68 vaping-related deaths reported to the Centers for Disease Control and Prevention (CDC) (Centers for Disease Control and Prevention, 2019a). While there is not one specific compound responsible for all cases of EVALI, a strong correlation exists between patients who have recently used e-liquids that contain tetrahydrocannabinol (THC) and increased incidence of EVALI. Bronchoalveolar lavage samples of affected patients have identified vitamin e acetate as the primary offending agent in EVALI cases. Vitamin E acetate is commonly mixed with THC containing e-liquids as a thickening agent (Jatlaoui et al., 2019). Although vitamin E acetate is found in the lungs of most patients with EVALI, the FDA is still unsure of what other compounds could be contributing to the illnesses. Thus, the FDA and CDC both strongly advise against the use of any e-cigarette product until all causes of EVALI can be identified. Prior to hospitalization, many patients suffering from vaping-related respiratory

illnesses reported symptoms of dyspnea, shortness of breath, chest pain, as well as vomiting, diarrhea, fever, and fatigue (Sharpless, 2019).

Incidences of other dangerous lung conditions associated with vaping are also on the rise. One of these illnesses, lipoid pneumonia, has been reported in numerous cases across the U.S. Researchers have cited the oil-based glycerol contained in e-liquids as the primary cause, which, when inhaled, results in respiratory distress and some instances of respiratory failure (Itoh et al., 2017; Viswam et al., 2018).

Other e-liquid flavoring components have also been proven harmful when inhaled. For example, menthol and ethyl maltol, commonly found in e-liquids, are chemicals known to have cytotoxic properties (Omaiye et al., 2019). A study that detailed the chemical composition of e-liquid flavors found that many contained 30 and 100 times the cytotoxic level of menthol and ethyl maltol, respectively. Cinnamaldehyde is another commonly used flavoring agent in sweet and cinnamon flavors of e-liquid that is known to directly cause DNA strand destruction, resulting in cell death when inhaled (Kaisar et al., 2016; National Academies of Sciences, Engineering, and Medicine et al., 2018; Rigotti & Kalkhoran, 2019).

Carcinogens such as formaldehyde and benzaldehyde can be created during the heating process of vaping and have been detected in high amounts in e-cigarette vapor (Goniewicz et al., 2014; Kaisar et al., 2016; National Academies of Sciences, Engineering, and Medicine et al., 2018; Offermann, 2015; Rigotti & Kalkhoran, 2019; U.S. Department of Health and Human Services, 2016). The magnitude of voltage used to heat the liquid directly affects how much aldehyde is formed while vaping. Kosmider et al. (2014) found that increasing the voltage in an e-cigarette from 3.2 volts to 4.8 volts resulted in the formation of 4-200 times the amount of carcinogenic compounds (formaldehyde, benzaldehyde, and acetone) yielded.

Twenty-six percent of teens who vape admit to manually dropping e-liquid directly on a heating coil and then immediately inhaling the aerosol, a process known as “dripping.” Dripping exposes teens to exponentially higher amounts of carcinogenic byproducts due to the higher aerosolization temperatures and is also dangerous because it involves close proximity with an extremely hot liquid that can result in burns (Krishnan-Sarin et al., 2017; Talih et al., 2016).

Furthermore, researchers have identified multiple heavy metals in e-cigarette aerosol and found that the metals are created during the reaction between the metal heating coil and e-liquid inside the heating chamber. This reaction results in the formation of cadmium, chromium, copper, nickel, lead, tin, manganese, arsenic, and zinc, which are toxic to the human body when inhaled (Goniewicz et al., 2014; Hess et al., 2017; National Academies of Sciences, Engineering, and Medicine et al., 2018; Offermann, 2015; Olmedo et al., 2018; Rigotti & Kalkhoran, 2019; U.S. Department of Health and Human Services, 2016). Heavy metals are more readily absorbed when inhaled than when ingested and can lead to neurotoxicity, cardiovascular disease, and lung cancer (Marcellin, 2019). Other toxic volatile organic chemicals such as acrylonitrile, propylene oxide, acrylamide, and crotonaldehyde have been found in the urine of adolescent e-cigarette users in much higher quantities than those that do not use e-cigarettes (Rubinstein et al., 2018).

Vaping also induces oxidative stress and inflammation throughout the lung tissue, decreasing forced expiratory volume, and causing greater amounts of nitric oxide to be retained during expiration (Eltorai, Choi, & Eltorai, 2019). It has been shown that smoking e-cigarettes can damage heart tissue leading to increased prevalence and severity of cardiac defects. Immunologically, e-cigarettes can cause increased inflammation and decreased neutrophil and macrophage efficiency, leading to greater cell death in alveolar cells and decreased immunity to viral and bacterial pathogens (Eltorai, Choi, & Eltorai, 2019).

E-cigarettes have also been known to explode, causing mild to severe injuries. In 2016, 1,007 patients were treated in the U.S. for burns related to e-cigarette explosions. The most common injuries were second or third-degree burns on the face, hands, thighs, and genitals. The explosions have also resulted in lacerations, broken necks, and shattered teeth. The first death from an e-cigarette explosion occurred in 2018 when the brain was hit by shrapnel from the blast (Seitz & Kabir, 2018).

The dangers of vaping also extend to accidental nicotine poisonings. The densely concentrated amount of nicotine present in e-liquid is made to be rapidly absorbed. Accidental spills on the skin have been reported, resulting in nicotine poisoning of differing degrees of severity in both adults and children. Symptoms of nicotine poisoning include nausea, vomiting, diarrhea, increased salivation, and respiratory secretions, bradycardia, seizures, respiratory depression, coma, and cardiac arrest (National Academies of Sciences, Engineering, and Medicine et al., 2018). Since 2013, over 20,000 calls have been made to the National Poison Data System (NPDS) regarding liquid nicotine exposures, thousands of which were exposures in children under the age of six who had either touched or swallowed e-liquid (American Association of Poison Control Centers, 2017; Govindarajan et al., 2018). In one case, a 15-month old child died after ingesting five milliliters of an e-liquid with a 10mg/mL concentration (Seo et al., 2016).

Because e-cigarettes are a relatively new product, there are no longitudinal studies available that detail the health effects of e-cigarettes in humans and specifically adolescents. With the limited available models and studies, it can be concluded that nicotine-containing e-cigarettes are addictive and potentiate neurologic and cognitive disorders in children and teenagers (U.S. Department of Health and Human Services, 2016). Thus, it is vitally important

for government regulatory bodies to act quickly to prevent injury and death related to e-cigarettes and e-liquids in children and adolescents.

### **Policy**

In the past, government entities have been slow to regulate tobacco products and marketing. For example, it became public knowledge that smoking causes lung cancer over 50 years ago. However, it was not until 2009 that Congress established the Family Smoking Prevention and Control Act, which gave the FDA license to regulate the manufacturing, distribution, and marketing of tobacco products (U.S. Department of Health and Human Services, 2016). At that time, e-cigarettes were not legally considered “tobacco products” because they contain only nicotine and not whole leaf tobacco. Because of this legality, e-cigarettes were left practically free from regulation for the next seven years, during which time, the market for e-cigarettes grew exponentially. The FDA repeatedly attempted to restrict sales of vaping products but were unsuccessful because e-cigarettes needed to be officially designated as a tobacco product before they could be subject to FDA regulation. In 2016, the “Deeming Rule,” was passed which expanded the FDA’s regulatory authority to incorporate e-cigarettes and e-liquids into the original law (United States Food and Drug Administration, 2016). The Deeming Rule prohibits sales of e-cigarette products to consumers under the age of 18 and the use of free samples to promote sales. It also restricts e-cigarettes from being sold in vending machines in areas where minors are present and requires mandatory warning labels to be placed on nicotine-containing products. Furthermore, the new law requires e-cigarette manufacturers and distributors to receive marketing authorization from the FDA and mandates compliance with established legal requirements of tobacco manufacturers (United States Food and Drug Administration, 2017).

As a part of the Deeming Rule, the FDA required e-cigarette manufacturers to disclose ingredient lists and documents on known health effects of their products, thus subjecting all products to pre-market review and proof of public health benefit (U.S. Department of Health and Human Services, 2016). This new regulation met major resistance from large tobacco companies and pro-vaping groups. These groups insisted e-cigarettes remain free from heavy regulation because of their potential to help adult smokers quit smoking, a claim that is passionately debated in current literature.

In response, the FDA extended the 2018 deadline of the Deeming Rule to the year 2022. This four-year extension was legally challenged by a team of public health authorities including the Campaign for Tobacco-Free Kids, the American Heart Association, the American Lung Association, the American Academy of Pediatrics, American Cancer Society Cancer Action Network, Truth Initiative, and five individual pediatricians because delayed action would worsen the teenage vaping epidemic (American Academy of Pediatrics, et al. v. United States Food and Drug Administration, et al., 2019; Jenssen et al., 2019). In July 2019, the public health organizations won the lawsuit filed against the FDA, which overruled the extended deadline. As a result of the legal decision, all e-cigarette products are now subject to premarket review, and manufacturers are legally required to submit products and ingredient lists for public health evaluation by May of 2020 or their products will be pulled from the market (American Heart Association, 2019).

## **Prevention Strategies**

### ***Parental Prevention***

Studies have shown that parental intervention is a significant factor in youth tobacco prevention (Thomas, Baker, & Thomas, 2016). Specific parenting strategies found to be

effective are setting limits, communicating openly with children about substance abuse, and assisting children with developing social skills to resist peer pressure. Tobacco prevention interventions were found to be much more effective when taught in the home and at school, rather than only in school settings. Multiple resources exist for parents to become acquainted with e-cigarettes and how to talk with children about vaping. These include information sheets and websites created by the CDC, the American Lung Association, the Surgeon General, the Campaign for Tobacco-Free Kids, Partnership for Drug-Free Kids, Tobacco Free California, and the American Academy of Pediatrics (American Academy of Pediatrics, 2019a; American Lung Association, 2019; California Tobacco Control Program, 2019; Centers for Disease Control and Prevention, 2019b; Centers for Disease Control and Prevention, 2019c; Partnership for Drug-Free Kids, 2019; Tobacco Free California, 2019).

### ***School and Community Prevention***

School-based interventions have also been shown to be effective at short-term tobacco prevention and, in one systematic review, were shown to have decreased youth intention to smoke by 12% (Das et al., 2016; Duncan et al., 2018; Rigotti & Kalkhoran, 2019; Towns et al., 2017). Studies show that the most effective programs for youth focus on building social skills, problem-solving, and resisting peer pressure. Resources for use in school and community settings include toolboxes and presentations specifically created for youth education, including the Not On Tobacco Program (NOT) supported by the American Lung Association (United States Food and Drug Administration, 2018), the Stanford Medicine Tobacco Prevention Toolkit (Stanford Medicine, 2019), the Make Smoking History toolkit (Massachusetts Tobacco Cessation and Prevention Program, 2019), the CATCH My Breath E-cigarette prevention program (Catch Global Foundation, 2019), the Minnesota toolkit (Minnesota Department of Health, 2019),

SmokeSCREEN videogame for teacher implementation (Yale University, 2019), the Scholastic Real Cost of Vaping Program (Scholastic, 2019), and the CDC's Youth Guide to E-cigarettes presentation (Centers for Disease Control and Prevention, 2019d). While not nearly as effective as parental-based interventions, school, and community-based tobacco prevention programs are moderately effective at preventing tobacco use in teens (Das et al., 2016; Thomas et al., 2016).

### **Healthcare Provider Intervention**

Many studies have shown that practitioner-led interventions can be effective in preventing and reducing youth tobacco use (Duncan et al., 2018; Farber et al., 2015; Hagan, Shaw, & Duncan, 2008; Pbert et al., 2015; Thomas et al., 2016; Tobacco Use and Dependence Guideline Panel, 2008). Healthcare providers have the opportunity to teach adolescents about the negative health effects of e-cigarette use during a time and in a setting where receptivity may be higher than at home or school. Healthcare providers are adolescents' preferred source of information regarding tobacco prevention and cessation (Pbert et al., 2015). Furthermore, the perception of e-cigarettes as being addictive and harmful is a protective factor against youth e-cigarette initiation (Kwon et al., 2018), and teenagers who are advised to quit by their healthcare provider are more likely to do so. Effective strategies for prevention include practitioners actively screening for e-cigarette use during patient visits, as well as providing information about why vaping is harmful, and discussing strategies to avoid initiation (American Academy of Pediatrics, 2015).

### ***The 5 A's***

The American Academy of Pediatrics (AAP), as well as numerous other organizations (Alberta Health Services, 2014; American Academy of Pediatrics, 2015), suggests using the "5 A's" screening and intervention model (ask, advise, assess, assist, and arrange follow up)



adapted from the U.S. Public Health Service Clinical Practice Guidelines to counsel with pediatric patients about e-cigarette use (Farber et al., 2015; Tobacco Use and Dependence Guideline Panel, 2008). The Bright Futures Guidelines inserts a precursory “A” which stands for “anticipate” to the beginning of the model (Hagan et al., 2008). A practitioner should anticipate that any patient could be exposed to, actively using, or be vulnerable to future use of any tobacco product. Guidelines suggest interviewing the patient without the parent present in the room to ensure privacy when discussing sensitive matters such as e-cigarette use.

**1) Ask.** First, it is strongly recommended that practitioners ask about all types of tobacco smoke exposure with every patient. Bright Futures suggests that first asking about friends’ e-cigarette use can help the patient feel more comfortable with being questioned about their use. Examples of these questions include; “Do any of your friends use e-cigarettes, e-hookah, or vape?” and “Have you tried an e-cigarette, e-hookah, or vape?” If the patient denies use, the provider should give positive reinforcement but also take the opportunity to ask the patient why he/she has chosen not to vape and discuss strategies to resist e-cigarette advertising and peer pressure (Farber et al., 2015; Pbert et al., 2015; Tobacco Use and Dependence Guideline Panel, 2008).

**2) Advise.** Second, if the patient admits to past or current e-cigarette use, the practitioner should strongly advise the patient to discontinue use and clearly explain the harms associated with the beginning or continuing to vape. This interventional step should be a discussion rather than a lecture and should be personalized to the needs of the patient. Experts have found that adolescent tobacco users are often interested in quitting, especially when the practitioner uses truths about e-cigarette prevention that pertain specifically to teenagers (Alberta Health Services, 2014; American Academy of Pediatrics, 2015). Messages that seem most effective for teens

focus on the loss of independence that comes from addiction, the damaging effect of nicotine on the developing brain, and that tobacco companies are manipulating teenagers into getting addicted to nicotine to replace the dying smoker population. The AAP suggests the provider empowers the patient by showing faith that the patient can quit, giving ample encouragement, and offering to help the patient through the process (Pbert et al., 2015; Towns et al., 2017).

**3) Assess.** Third, the healthcare provider should assess the level of dependence associated with the patient's e-cigarette use to understand best how to help the patient quit. Questions could include asking what products the patient uses, why he/she vapes, how often he/she vapes, how long per session, if he/she has experienced withdrawal symptoms, how quickly withdrawal symptoms appear after use, and if he/she has ever tried to quit previously. The Modified Fagerstrom Tolerance Questionnaire, the "Hooked on Nicotine Checklist" (HONC), and the Youth Multidimensional Dependence Assessment Tool are resources that providers can use to assess their patient's potential to become dependent on nicotine or active level of nicotine dependence (Alberta Health Services, 2014; DiFranza et al., 2002; Towns et al., 2017). No data were found that suggest one tool is more effective than another.

The practitioner should also assess the adolescent's readiness to quit. Readiness to quit can be measured by directly asking the patient how ready he/she is to quit, what barriers he/she sees to quitting, how important it is for him/her to quit, and how confident he/she is in their ability to quit (Pbert et al., 2015). A practitioner can also use the "Tobacco Use and Quitting Self Evaluation Tool" to help the patient self-identify how ready they are to quit using e-cigarettes (Optima Health, 2019). Furthermore, the practitioner must understand that e-cigarette use may be a way that a teen has chosen to cope with an underlying disorder that needs to be

treated. Thus, the provider must carefully assess for any signs of mental or physical health conditions or a history of abuse (Farber et al., 2015; Hwang & Park, 2016).

**4) Assist.** Fourth, the practitioner should assist the patient in stopping the use of e-cigarettes, or at least decrease e-cigarette use if the patient is unwilling to stop at this time. Appropriate treatment for patients who use e-cigarettes includes working with the patient to set specific goals customized to the patient's readiness to quit.

***Ready to quit.*** If the patient is ready to quit, the practitioner can set a quit date with the patient and make a detailed plan, including the use of medications, if necessary (Alberta Health Services, 2014). The clinician should ask the patient to detail barriers they see to quitting and their specific triggers to vape. Also, clinicians should ask about the environment in which the patient usually vapes, and other influences that reinforce the habit. Ask the patient to name the things that weaken their desire to vape and a list of supportive and positive influences such as exercise, friends, family, and other coping mechanisms. The provider should then help the patient understand withdrawal symptoms and establish readily accessible resources for the patient to use when withdrawals become hard to manage (Pbert et al., 2015). If the parents/primary caregiver does not yet know about the patient's e-cigarette use, offer to help the patient tell them about the problem and the quit plan, thus allowing them to receive an optimum level of support through the process.

***Considering quitting.*** If the patient is considering quitting, the clinician can provide positive reinforcement, and ask the patient to explain what is important to him/her about quitting. The practitioner should also identify barriers and detail positive influences as well as give additional benefits associated with quitting and discuss quitting resources available to the patient when he/she feels ready. Lastly, help the patient make a small goal that he/she can begin

working on immediately. An example would be keeping a tobacco use log that can help the patient identify triggers and discover how their body responds to nicotine withdrawals, thus helping him/her to gather information for a quit attempt in the future (University of California, San Francisco, Schools of Pharmacy and Medicine, 2019a).

***Not ready to quit.*** For teenage patients who are unwilling to quit, the AAP recommends using a motivational counseling method called the “5R’s” which stands for relevance, risks, rewards, roadblocks, and repetition (Farber et al., 2015; Pbert et al., 2015). a) Relevance: Discuss with the patient why quitting would be important to him/her. b) Risks: Ask the patient to talk about the risks and side effects associated with continuing to use e-cigarettes. c) Rewards: Ask the patient to explain the benefits of quitting that would be important to him/her. d) Roadblocks: Ask the patient about what barriers are preventing him/her from quitting. e) Repetition: Repeat this method during each subsequent visit with the patient, helping the patient to understand that it often takes many quit attempts before achieving success. The practitioner can also provide the patient with information about the harms and dangers of vaping and the rewards associated with cessation in a non-judgmental manner. Lastly, the practitioner should help the patient understand that help is available to him/her as soon as he/she is ready to consider quitting.

**5) Adequate follow up.** Fifth, for the patients who agree to treatment, the primary care provider must ensure adequate follow up is provided. Well-organized follow-up with adolescent patients has been shown to increase compliance with treatment plans and decrease the chances of relapse (Farber et al., 2015; Pepper et al., 2015). To initiate this process, the provider can discuss with the patient a method and a period of time to follow up on his/her progress. Current guidelines suggest following up with patients who are attempting to quit at least once within the

first week, and then a second time within the next month. For adolescent patients not willing to quit, follow up can be provided at the next clinic visit.

If upon follow up, the provider discovers that the patient has relapsed and is continuing to use e-cigarettes, a three-step protocol using an adjusted “AAR” method can also be used: 1) Ask about the quit attempt, what treatments or coping strategies the patient had used, and how the treatment worked for the patient. 2) Advise the patient to try again using a combination of treatment options. 3) Refer the patient to a behavioral change program if he/she is not already involved in one (University of California, San Francisco, Schools of Pharmacy and Medicine, 2019b).

### **Treatment**

Reference guides and training programs exist that can help practitioners to learn tobacco cessation strategies specific to the adolescent population. These include the 2008 Treating Tobacco Use and Dependence: Clinical Practice Guideline (Tobacco Use and Dependence Guideline Panel, 2008), the American Academy of Pediatrics reference documents (American Academy of Pediatrics, 2015; American Academy of Pediatrics, 2019b), Tobacco Free Futures Guidelines (Alberta Health Services, 2014), State-of-the-Art office-based interventions to eliminate youth tobacco use: the past decade (Pbert et al., 2015), UpToDate (Rosen & Sockrider, 2019; Sockrider & Rosen, 2019), Optima health clinical guidelines for tobacco cessation and e-cigarette use (Optima Health, 2019), the Rx for Change module training series (University of California, San Francisco, Schools of Pharmacy and Medicine, 2019c), Kids Quit physician training modules (The Children’s Hospital at Westmead, 2019), and Smokefree.gov resources for physicians (National Institute of Health, 2019a).

Published guidelines detailing the treatment of adolescent nicotine addiction suggest the best approach is multifaceted and should include both behavioral and pharmacological interventions. Unfortunately, published data on the effectiveness of behavioral or medicinal treatments for e-cigarette use does not yet exist and no nicotine replacement therapies are FDA approved for use in adolescent patients. Therefore, the current recommendation for treatment is to refer to the provider's discretion until more research can be done (Alberta Health Services, 2014).

Published guidelines suggest that when counseling a patient about his/her e-cigarette use, two separate issues associated with nicotine dependence need to be addressed: the habitual behavior of using the nicotine delivery device and the physiological dependence on nicotine (University of California, San Francisco, Schools of Pharmacy and Medicine, 2019c). Thus, both the behavioral and physiological needs of the patient should be addressed in treatment.

### ***Behavioral Interventions***

Counseling is the first-line treatment in adolescents who use tobacco products and has been shown to double youth tobacco abstinence rates when compared with no intervention (Tobacco Use and Dependence Guideline Panel, 2008). However, evidence has not yet identified which aspect or form of counseling has the highest success rate (Peirson et al., 2016). Because of this, the 2008 Treating Tobacco Use and Dependence: Clinical Practice Guideline, AAP, Cochrane Database, and all existing practice guidelines suggest using a mixture of targeted behavioral techniques for treatment of teens who use tobacco products. Studies have shown that youth are 34% more likely to follow through with a quit attempt when clinicians used behavioral interventions (Canadian Task Force on Preventive Health Care, 2017). Programs proven to help with smoking cessation in adolescents included the use of social influence, positive media, anti-

vaping peer pressure, cognitive-behavioral strategies, stress management techniques, and motivational enhancement (Towns et al., 2017).

Furthermore, the 2008 Treating Tobacco Use and Dependence: Clinical Practice Guideline states that adolescents treated with a combination of therapies, such as counseling with a practitioner paired with motivational interviewing, interactive computer interventions, or mobile-based interventions, are more likely to be successful in their quit attempt. Providers can refer to counseling services for patients where more thorough counseling is needed, or for specific treatments such as cognitive-based therapy (CBT) which is effective in treating teenage e-cigarette use (Duncan et al., 2018; Harvey & Chadi, 2016; Simon et al., 2015). Coping or distraction strategies suggested by various guidelines include the use of support groups, talk therapy, guided imagery, positive self-talk, meaningful distractions, exercise, sports, hobbies, calling a friend, deep breathing, yoga or mindfulness tactics to distract from cravings.

Internet and mobile-based intervention methods are becoming more popular as anti-vaping aids, but more research must be done before effectiveness can be documented (Alberta Health Services, 2014). Computer and internet-based resources for e-cigarette cessation include The Real Cost campaign (U.S. Department of Health and Human Services, 2019), Truth Initiative (Truth Initiative, 2019), Smokefree Teen (National Institute of Health, 2019b), My Life My Quit (National Jewish Health, 2019) and many others. One small pilot study showed that videogames could be effective at increasing youth awareness of e-cigarettes and decreasing initiation. A randomized control trial done in 2018 found that short-term exposure to a videogame that challenged traditional beliefs and attitudes about e-cigarettes could aid in youth vaping prevention by altering risk factors that ultimately lead to the initiation, such as lack of knowledge about the health effects of vaping (O'Connor et al., 2019; Pentz et al., 2019).

Another means to prevent teenage e-cigarette use is personalized mobile messages with anti-vaping themes. Studies have shown that at least 90% of teenagers own a mobile phone and most cite text messaging as their preferred method of communication (Noar et al., 2019). Research has shown that text messaging-based interventions are proven to help smokers with cessation when compared with controls and may be effective with youth tobacco prevention and cessation (Scott-Sheldon et al., 2016; Simon et al., 2015).

### ***Pharmacological Interventions***

To help a teenager to quit using e-cigarettes, the physiological addiction to nicotine may need to be addressed and attenuated with nicotine replacement therapies. The 2008 Treating Tobacco Use and Dependence: Clinical Practice Guideline states that although nicotine replacement therapies (NRT) are not FDA approved for use in patients under 18, nicotine replacement is safe in adolescents and may be effective in short-term abstinence (Tobacco Use and Dependence Guideline Panel, 2008). Although nicotine in any form or amount is harmful to adolescents, healthcare providers understand that if the patient is already absorbing high amounts of nicotine via e-cigarette use, the patient can potentially decrease nicotine exposure and may be able to stop vaping using NRT. Thus, multiple guidelines and studies conclude that pharmacotherapy for adolescent e-cigarette cessation can be considered if there is evidence of tobacco dependence and the patient has a desire to quit smoking (Alberta Health Services, 2014; Myung et al., 2019; Pbert et al., 2015; Rosen & Sockrider, 2019; Siqueira & AAP COMMITTEE ON SUBSTANCE USE AND PREVENTION, 2017; Tobacco Use and Dependence Guideline Panel, 2008). However, healthcare providers must be diligent with follow up and monitor for adverse effects or lack of compliance with treatment.



Nicotine replacement therapies use a long-acting form of nicotine that is slowly absorbed to attenuate the withdrawal symptoms associated with stopping tobacco use. These medications have low abuse potential but can have side effects such as local skin or membrane irritation, and increased heart rate and blood pressure. The dose, frequency, and length of nicotine replacement treatment time should be titrated to the needs of the patient to reduce withdrawal symptoms to a manageable level. Studies have shown that in adolescent patients, use of NRT can help with short-term abstinence but does not significantly influence long-term cessation (Pbert et al., 2015). The available forms of NRT include patches, gum, lozenges, nasal spray and inhalers. For the adolescent patient, nicotine patches and gum are the most effective and well-tolerated (Rosen & Sockrider, 2019). These products are available by prescription to patients under the age of 18 and dosages can be titrated to the patient's level of nicotine dependence.

Bupropion (Wellbutrin) is an antidepressant medication that acts on the dopamine and norepinephrine neurotransmitters in the brain. It can be used to aid in several types of addictions as it helps to stabilize dopamine levels in the brain. Although the results are mixed, some studies do suggest that the use of bupropion for nicotine cessation can be effective in the short-term (four weeks) treatment of adolescent smokers (Myung et al., 2019). However, bupropion was not shown to be effective at maintaining abstinence from tobacco at 52 weeks. Clinicians should be aware that bupropion also has potential side effects, including suicidal ideation, insomnia, headache, agitation, tremors, tachycardia, diaphoresis, nausea and vomiting.

Varenicline (Chantix) is a partial nicotinic agonist that is used for tobacco cessation in adults. In 2019, a randomized control trial involving adolescents found no significant evidence that the use of varenicline contributed to tobacco cessation in youth aged 12-16 (United States Food and Drug Administration, 2019). The common side effects of taking varenicline include

headache, nausea, vomiting, constipation, irritability, suicidal ideation, depression, and sleep disturbances. Reference guides such as UpToDate do not recommend varenicline as an appropriate treatment for adolescents due to the severity of side effects and lack of efficacy in documented clinical trials (Rosen & Sockrider, 2019).

## **Methods**

### **Review of Literature**

The literature review was utilized to create the education module. A comprehensive literature review of scholarly articles regarding adolescent e-cigarette use was conducted. Data for the literature review were identified using the search engines CINAHL, MEDLINE, UpToDate, Cochran Database, Academic Search Ultimate, Education Full Text, and Google Scholar. Search terms included: (vap\* or e-cig\* or electronic nicotine delivery system\* or electronic vapor products or ENDS) AND (adolescent\* or teen\*). During the original search, only articles that were published within the last five years (2014-2019) and in the English language were included. Articles used for references were chosen based on relatability to e-cigarette use in the adolescent population. Due to a limited number of studies that address only e-cigarette prevention and cessation in the adolescent population, the findings of studies that generalized e-cigarette use into broader categories of tobacco use or smoking in adolescents were also included. The author used references from the articles yielded in the original search to locate alternative articles with significant findings. Information from the collection of articles was then analyzed and reported in the literature review section of this paper.

### **Creation of the Education Module**

The overall purpose of the module is to train healthcare providers about e-cigarette use in the adolescent population and give providers the tools needed to diagnose and treat adolescent e-

cigarette use appropriately. It was decided that this goal would be best achieved by including a 1) thorough background of the history and anatomy of e-cigarettes; 2) why e-cigarette use is common among teens; 3) what health effects occur in teens as a result of e-cigarette use; 4) what steps have been taken federally to decrease teen e-cigarette use; 5) the most effective methods of teen e-cigarette use prevention; and 5) current recommendations on treatment of adolescent nicotine use specific to e-cigarettes. The most recent and relevant information regarding these aspects of teenage e-cigarette use was chosen from the literature review to be included in the presentation.

The education module was initially created using Microsoft PowerPoint. The presentation was then converted into an interactive module format using the program Adobe Captivate®. A script was written, edited by members of the committee, and then rewritten and revised. A voice-over was added to the module and graphics were developed and included. Pictures were identified by using the “labeled for reuse” feature of Google Images so as not to include any copyrighted material. The piloted module was approximately 60 minutes in length as requested by the American Association of Nurse Practitioners (AANP).

### **Participants**

Participants were asked to complete and critique the first draft of the education module. Participants were recruited using snowball sampling and were not given any form of financial or other compensation. To be eligible, the participant needed to be an actively practicing nurse practitioner. All nurse practitioner specialties were eligible to participate (i.e. FNP, PNP, ACNP, etc.).

### **Evaluation of Module Effectiveness**

In order to evaluate the effectiveness of the module, participants answered a series of 12 questions about e-cigarette use in the adolescent population before and after viewing the module (see Appendix A). These questions were developed using specific learning objectives which included: 1) being able to differentiate between various types of electronic cigarettes; 2) state multiple vulnerabilities of the adolescent population in regard to e-cigarette use; 3) identify adverse health effects associated with vaping; 4) correctly educate pediatric patients and their parents about vaping; 5) use the “5 A’s method” to screen for, prevent, and treat teenage nicotine use disorder; and 6) understand behavioral and pharmacological treatments for adolescents who vape. Questions were also asked about the demographics of the participants, including age, gender, education, and employment (see Appendix A). Lastly, participants were asked one open-ended question about suggestions for module improvement.

After completing the module, participants were asked the same 12 questions addressing the learning objectives of the module, and individuals’ post-test scores were compared to their pre-test scores to assess improvement. Participants’ feedback was also analyzed, and three themes were generated from the results.

### **Outcome**

The following education module: “An Evidence-Based Approach to Understanding and Treating Electronic Cigarette Use in the Adolescent Population.”

Link: [E-Cig Module](#)

### **Results**

The first draft of the module was piloted by a convenience sample of 12 nurse practitioners. Of the 12 participants, two identified as being age 30-40, two were age 40-50, six

were age 50-60, and two were age 60-70. Eleven of the participants were female and one was male. Four of the participants indicated their highest level of education was a master's degree and eight indicated their highest level of education was a doctorate degree. Five participants noted that they worked primarily in outpatient healthcare, one in inpatient healthcare, one in primary care, one in residential healthcare, and three in nursing academia.

The effectiveness of the piloted module was measured using the participant's responses to 12 questions before and after completing the module: "An Evidence-Based Approach to Understanding and Treating Electronic Cigarette Use in the Adolescent Population." The purpose of the pre- and post-testing was to answer the questions: "By how much does a nurse practitioner's general understanding of electronic cigarette use in the adolescent population improve after completion of the module?"; "By how much does a nurse practitioner's understanding of treatment for adolescent nicotine cessation improve after completion of the module?"; and, "In what ways can the module be improved?"

Before viewing the educational module, the average test score was 4.6 correct responses out of 10. After viewing the module, participants answered an average of 7.7 questions correctly out of 10. Post-test participant scores improved on average by 30.8% or by 3.08 more correctly answered questions. The difference between the participants' knowledge before and after completing the module was significant ( $t(11)=5.4, p=0.001$ ). Of the 12 participants, 83% indicated that their general understanding of e-cigarette use in the adolescent population improved and 83% indicated that their understanding of available treatment options for adolescent nicotine cessation improved.

Furthermore, nine of the participants provided extensive feedback on how different aspects of the module could be improved. First, five of the 12 participants noted that the pilot

module was too long. Second, three participants remarked that they would like the presentation to be more engaging. For example, one participant said, “(the module) was a little boring to just listen to.” Another participant suggested, “having words appear on the screen line by line as the narrator is saying them” to keep listeners engaged. Third, two participants commented that the presentation slides included too much text and should highlight only the most important points. One participant suggested that the script be added to the paper as an Appendix, but this feedback was disregarded because the information for the script is very similar to the information included in the literature review.

### **Final Updates to Module**

As a result of the participants’ feedback, the module was updated and re-recorded. First, the content of the piloted module was carefully reviewed and updated to ensure all content specifically aligned with the learning outcomes. Second, the author updated the module to have words appear line by line in tandem with the voice of the narrator. Third, the author reduced the amount of text present on each slide and only included headings and summaries of information as suggested by participants. The module was then updated with the necessary changes and re-recorded but modified to 50 minutes in length. Once complete, the finalized module was shared with AANP, as per AANP’s request, to be used as a continuing education module for nurse practitioners.

### **Discussion**

This project resulted in the development of an online module for nurse practitioners about adolescent e-cigarette use. Although the sample size was relatively small, reviewers indicated that they were better prepared to educate their adolescent patients about e-cigarette use, as well as screen for and treat nicotine dependence in this population, after completing the module.

These results are consistent with those found in a 2014 systematic review exploring effectiveness of e-learning in pharmacy education (Salter et al., 2014). This systematic review reported on 11 different studies that applied e-learning in pharmacy, and then measured improvement of knowledge using pre and post intervention tests. E-learning significantly improved participants' understanding of educational material in all 11 studies.

Online continuing education learning modules are commonly used for nurse practitioners to stay up-to-date on the latest evidence. E-learning allows flexibility and is a cost-effective approach to continuing education (Rostad, Grov, & Moen, 2014). While e-learning is generally well-received, the effects of e-learning on caregiver practice are difficult to measure (Sinclair et al., 2015).

This project was unique because it focused specifically on improving nurse practitioners' understanding of e-cigarette use in the adolescent population. After viewing the module, participants' tests scores improved, indicating that their understanding of e-cigarettes improved. However, none of the participants were able to answer all of the questions correctly, revealing that effectiveness of the module could be enhanced. Lastly, while the use of e-learning significantly improved knowledge of subject matter in this and other studies, no studies to date have been able to measure the long-term effectiveness of e-learning on clinical practice (Salter et al., 2014). Additional follow-up is needed to determine if this module about e-cigarette use in adolescents changes nurse practitioners' practice and subsequent patient outcomes (Rouleau et al., 2019).

### **Limitations**

Limitations of this study included a small sample size, absence of random sampling, and a lack of diversity in the studied population. Because of these factors, this study may not be generalizable to all populations.

### **Future Research**

Further development of this project should include measuring the long-term effects of the provided education on nurse practitioners' practice. Additional research is needed to discover which formats or aspects of e-learning are the most effective at changing clinician practice.

### **Conclusion**

The purpose of this module was to educate nurse practitioners on the subject of e-cigarettes and their effects on adolescent health, as well as provide treatment guidelines for nicotine dependence in teens who vape. Education was provided in the form of an internet-based, e-learning module addressing these subjects in detail. Effectiveness of the module was measured using results of a pre and post-intervention test completed by 12 nurse practitioners. Test scores improved significantly after viewing the module, and 83% of participants self-reported that their understanding of e-cigarette use in the teenage population improved after completing the module. Clinicians are more likely to screen for and educate their pediatric patients about vaping when their own understanding of e-cigarettes is improved. Thus, this module can be used to help nurse practitioners counter the ever-rising number of teens who vape by improving their understanding of e-cigarette use in the adolescent population.



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## Appendix A

**Questionnaire for Pre and Post-Test**

1. How many high school and middle school aged teens currently use e-cigarettes nationally?

- a) **1 in 4 high school students and 1 in 10 middle school students**
- b) 1 in 6 high school students and 1 in 12 middle school students
- c) 1 in 10 high school students and 1 in 15 middle school students
- d) 1 in 5 high school students and 1 in 6 middle school students

2. JUUL products always contain nicotine. True or False.

- a) **True**
- b) False

3. JUUL and related products are different from typical e-cigarettes because they...

(Choose all that apply)

- a) Contain less nicotine per puff than typical e-cigarettes and are generally safer to use
- b) Contain only flavorings and water vapor
- c) **Are shaped like USB sticks and are easy to use discreetly**
- d) **Contain nicotine salts which are more potent than the freebase nicotine contained in most e-cigarette products**

4. Which statement is correct concerning e-liquids?

- a) There are approximately 100 different flavor options available for purchase
- b) Around 50% of e-liquids on the market contain nicotine
- c) Although ingredient lists are not usually included, the labelled nicotine amount is almost always consistent with the measured amount
- d) **Many of the ingredients used in e-liquids are deemed safe for consumption by the FDA, but not safe for inhalation**

5. Which answer is FALSE concerning teenage vulnerabilities to e-cigarette use

- a) Most teens think that the vapor in e-cigarettes is just water and flavoring
- b) **Most teens acquire their e-cigarettes from vape shops in their neighborhood**
- c) Curiosity and peer pressure are big reasons why teens try vaping for the first time
- d) E-cigarettes are cheaper to use than conventional cigarettes in the long run

6. Which answer is FALSE concerning how aggressive use of nicotine affects an adolescent's brain?

- a) Nicotine use in adolescence can cause lifelong incidence of depression, anxiety, and impulsivity
- b) Nicotine use can lead to lifelong addiction and increase affinity for other drugs including classic cigarettes
- c) **Although e-cigarettes can damage adolescent brain function, nicotine in and of itself does not negatively affect the teenage brain**
- d) Vaping e-liquids that contain nicotine can produce e-cigarette specific withdrawal symptoms

7. What is the additive responsible for the majority of cases of e-cigarette or vaping-use associated lung injury (EVALI)?
- a) Sorbitol
  - b) Artificial coloring
  - c) Vitamin E acetate**
  - d) EDTA
8. What does the “5 A’s” interventional approach include?
- a) Assume, Act, Acknowledge, Articulate, Apply
  - b) Advise, Acknowledge, Act, Apply, Accountable
  - c) Ask, Advise, Assess, Assist, Arrange follow-up**
  - d) Ask, Acknowledge, Advise, Act, Arrange follow-up
9. Your 15-year-old male patient just admitted to you that he currently uses e-cigarettes and would like help to quit. Which intervention would be LEAST appropriate?
- a) Develop a quit plan with the patient and discuss triggers, barriers, positive influences, coping strategies and useful resources
  - b) Refer the patient to a behavioral change program
  - c) Prescribe medications such as Bupropion and Chantix to aid with cessation attempts**
  - d) Prescribe nicotine patches or nicotine gum to help attenuate withdrawal symptoms
10. Which treatments are currently FDA approved for tobacco cessation in adolescent patients (under the age of 18)?
- a) Nicotine replacement therapies
  - b) Bupropion
  - c) Chantix
  - d) None of the above**
11. How would you rate your general understanding of electronic cigarette use in the adolescent population?
- a) Poor
  - b) Fair
  - c) Good
  - d) Very good
12. How would you rate your understanding of available treatment options for adolescent nicotine cessation?
- a) Poor
  - b) Fair
  - c) Good
  - d) Very good
13. About you: How old are you?
14. About you: What is your gender?

15. About you: What is your highest degree?

16. About you: Where do you work?

17. What feedback do you have about the module?