



# Vaping implications for children and youth

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## Purpose of review

The development and uptake of E cigarettes are a relatively recent phenomenon. Because of aggressive marketing, attractive designs, enticing flavors and primarily reactionary legislation, we are now seeing soaring rates of adolescent vaping with associated consequences. This review explores how E cigarettes work, their health implications, epidemiology among youth and current regulatory strategies.

## Recent findings

Recently, the Center for Disease Control and Prevention reported that 27% of high school students had used a tobacco product within the last month, the majority being E-cigarettes in 20.8% of high school students. Vaping has managed to reverse a decades long trend of declining nicotine use among youth. Long-term addiction is not the only concern related to youth vaping; there are also increasing reports of short-term health consequences, such as seizures, acute nicotine toxicity, burns and lung injury.

## Summary

Industry has created and aggressively marketed a product that is enticing to adolescents. E cigarettes have sleek designs, desirable flavors and social acceptability with perceived safety among youth. This has resulted in epidemic E cigarette use in youth with resultant significant short-term and long-term health concerns. Legislation must include regulations that strictly avoid marketing and sales to youth, as well as reducing access to these products.

## Keywords

E cigarettes, regulation, vaping, youth

## INTRODUCTION

Electronic cigarettes (E cigarettes) are the most commonly used nicotine products in North American youth. Initially marketed as smoking cessation devices for established smokers, these electronic nicotine delivery systems (ENDS) have established a strong foothold in previously nonsmoking adolescents and young adults thanks to creative and aggressive early marketing strategies specifically targeting this demographic, along with a delayed and in many jurisdictions inadequate regulatory response. Vaping is akin to a Pandora's box, as potential short-term and long-term health effects are as of yet poorly understood, but are rapidly unfolding and becoming realized in society. Pediatricians must be fully aware of this epidemic and actively engaged in a commitment toward understanding and reducing vaping-related harm in children and youth.

## WHAT IS IN A VAPE?

ENDS are commonly referred to as E cigarettes, E cigs or Vapes; they are electronic devices used to deliver nicotine and other substances, such as tetrahydrocannabinol (THC), cannabidiol and butane hash oil

(known as dabs) via an aerosol to the lungs [1]. These devices typically contain a rechargeable lithium ion battery, electrical heating coil and liquid (E liquid or E juice) in a disposable cartridge or refillable tank. During inhalation, the battery activates the heating coil, which turns the liquid into an aerosol that is inhaled or 'vaped' through the mouth piece [2<sup>a</sup>,3,4]. E cigarettes were initially developed as a smoking alternative and cessation aid (U.S. Patent No. 8,490,628 B2, 2013), and were designed to have an appearance similar to that of cigarettes in order to mimic the experience of smoking. There have since been numerous E cigarettes produced with varying appearances, some of which are larger with

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## KEY POINTS

- E cigarettes, specifically pod mods (i.e. JUUL), through aggressive marketing, sleek and inconspicuous design and enticing flavors, have led to a reversal of a decades long trend of declining adolescent nicotine use in North America.
- Health risks associated with E cigarette use are not yet fully known, but short-term and long-term effects thus far include: nicotine addiction and its associated consequences in youth exposure (e.g. adverse cognitive development), acute nicotine toxicity in users (e.g. seizures) and nonusers (e.g. unintentional ingestions in young children < 4 year), device malfunction resulting in burns and blast injuries, and a spectrum of respiratory effects, such as exacerbating asthma/bronchitis, bronchiolitis obliterans 'popcorn lung' and EVALI (lung injury).
- Legislation thus far has been reactionary as opposed to preventive. Although Canada and the United States are tightening legislation on marketing, sales and age restrictions, neither country goes far enough to ban flavored E liquid or at the time of writing has yet addressed concentration/toxicity or introduced taxation.
- Public education remains an important and effective tool in raising societal awareness; however, it MUST be accompanied by thoughtful but aggressive regulation to directly reverse the adverse consequences for youth.

refillable E liquid tank systems, and newer devices that are smaller and inconspicuous with disposable cartridges (Fig. 1). These more recent and ubiquitous ENDS are known as pod mods [2<sup>■</sup>,3,4]; the most popular of these is JUUL, first introduced to North America in 2015, with a novel USB-like appearance and disposable E liquid cartridge system and multiple flavors [5,6].

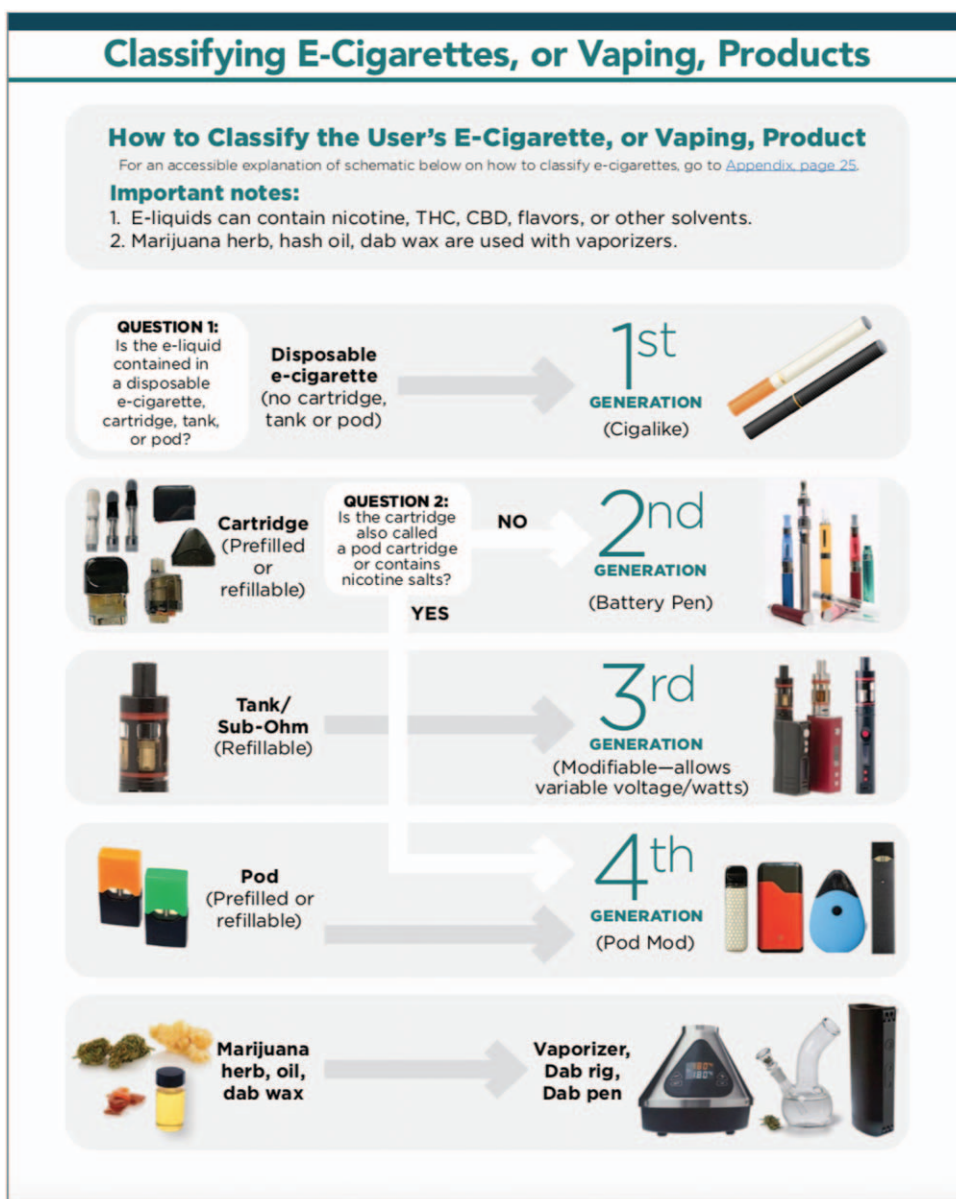
The vast majority of E liquids typically contain nicotine along with a solution of propylene glycol, added flavoring agents and other chemicals. E liquid is commercially available in a range of nicotine concentrations from 0 mg/mL (0%) to 59 mg/mL (5%). The accuracy of the marked concentrations is, however, questionable, with documented variability between labeled and actual measured concentrations [7]. A single JUUL cartridge with 5% nicotine is equivalent to 1 pack of cigarettes, and thus a JUUL starter pack available in Canada for \$39.99 (containing four cartridges, three of which are flavored, and a rechargeable JUUL device) is equivalent to four packs of cigarettes [8,9]. Nicotine levels in the E cigarette aerosol can be equal to or greater than levels found in traditional cigarette smoke [7,10]. This is dependent on the nicotine concentration in the E liquid, the

device, as well as the experience of the user. A more experienced user is able to generate higher concentrations of nicotine [10]. In addition, there is a trend for individuals to make their own E liquid, with nicotine concentrations in homemade products further deviating from commercial standards [11]. Vaping with JUUL devices especially, which contain nicotine salts, causes peak serum nicotine concentration within minutes of inhalation, similar to that of traditional cigarette smoking; thus, the rapid peak serum concentrations and smoother inhalation, combined with sleek and inconspicuous designs and sweet flavoring, create an addictive and enticing product [12,13,14<sup>■</sup>].

In addition to nicotine, toxic components, such as formaldehyde, acetaldehyde, acetone, and metals, and volatile organic compounds (VOCs) may also be present in the E liquid, or created during the heating process and present in the aerosol [15]. In an adult population-based cohort study VOCs, metals and nicotine metabolites were found in E cigarette user's urine at greater concentration than nonsmokers. Several VOCs and metals were found at concentrations equal to that of cigarette smokers, and the population with the highest concentrations were dual users [16]. Much press has recently surrounded the presence of vitamin E acetate in E liquid, which is used as a thickening agent in some E liquids (primarily those containing THC) and has been suggested as a culprit in the recent outbreak of acute lung injury related to vaping [17]. The long-term health effects of inhaling VOCs, metals, vitamin E acetate and other substances are as of yet unknown, but the increase in reporting of lung injury undeniably brings up serious health concerns.

## IMPACT OF VAPING ON HEALTH

Multiple different adverse events have been associated with E cigarettes, from seizures and acute pulmonary injury to explosions with resultant burns and blast effects. Seizures are a known potential side-effect of nicotine toxicity and have been reported after vaping. One hundred and seventeen cases of seizures related to vaping were reported to the Food and Drug Administration (FDA) from April 3, 2019 to June 30, 2019, and the majority were in adolescents or young adults [18]. In addition to intentional exposure to E cigarettes and E liquid, there is increasing unintentional exposures to E liquid, primarily among small children. A retrospective analysis involving the National Poison Data System published in 2016 demonstrated that the monthly number of exposures associated with E cigarettes increased by 1492.9% from 2012 to 2015. Children below 2 years old accounted for



**FIGURE 1.** Different types and generations of E cigarettes. Image from the Center for Disease Control and Prevention: E cigarettes, or Vaping, Products Visual Dictionary page 15: [https://www.cdc.gov/tobacco/basic\\_information/e-cigarettes/pdfs/ecigarette-or-vaping-products-visual-dictionary-508.pdf](https://www.cdc.gov/tobacco/basic_information/e-cigarettes/pdfs/ecigarette-or-vaping-products-visual-dictionary-508.pdf).

44.1% of unintentional E cigarette exposures. Children accidentally exposed to E cigarettes as opposed to traditional cigarettes had 5.2 times higher odds of a healthcare facility admission and 2.6 times higher odds of having a severe outcome. One death occurred related to liquid nicotine exposure [19].

More recently, E cigarette vaping use-associated lung injury (EVALI) has been recognized. As of November 5, 2019 there have been 2051 cases of EVALI and 39 deaths in the United States, and as of November 6, 2019, seven probable cases in Canada [17,20<sup>■</sup>,21]. At this time, EVALI has not been

definitively linked to a specific chemical substance or product in E liquid; however, recently, vitamin E acetate was found in the Broncho-alveolar lavage of all 29 cases of EVALI submitted to the Center for Disease Control and Prevention (CDC) from 10 states. People who vape THC may be at increased risk of EVALI, as 76.9% of cases report vaping THC within a month of developing EVALI and 56.8% report vaping nicotine; 36% report vaping THC only, whereas 16% report vaping only nicotine [20<sup>■</sup>].

Explosions and burns from E cigarettes are usually because of the rechargeable lithium ion

batteries, which contain flammable electrolyte solutions that can ignite or explode if overheated or escape the battery capsule [22]. There have been several deaths related to E cigarette explosions with projectiles to the head and neck, as well as nonlethal but life altering ocular injuries and significant burns requiring skin grafting [22,23]. Burns primarily affect the lower extremities (from E cigarettes placed in pockets) followed by the upper extremity and hands [23].

Nicotine itself is an extremely addictive substance and has been shown to affect the developing adolescent brain. Adolescents who smoke have been shown to have more difficulty with working memory and attention than nonsmokers [24,25]. In addition, the observation that adolescent smokers are more likely than adult smokers to become dependent on nicotine is well described, and data supports that nicotine has stronger rewarding effects in adolescents than adults [26]. The 2012 Surgeons General report reiterated the 1964 finding that the vast majority of adult smokers began before adulthood. Among adults aged 30–34 who ever smoked regularly, nearly 90% had first tried a cigarette before age 19, and 99% before age 26. More than one-third of adults who had ever tried a cigarette reported trying their first cigarette by age 14 [27]. The CDC recommends that E cigarette or vaping products should never be used by young adults [17].

## YOUTH VAPING: DEMOGRAPHIC CREEP

Current efforts have proven ineffective thus far in halting the rapid spread of vaping among adolescents. In 2018, the CDC reported that 27% of high school students had used a tobacco product within the last 30 days, the majority being E cigarettes in 20.8% of high school students [28<sup>11</sup>]. Use has increased rapidly over the last 7 years; in 2011, only 1.5% of high school students had tried E cigarettes compared to 20.8% in 2018. From 2017 to 2018 alone, the number of youth using E cigarettes increased from 2.1 to 3.6 million, the largest ever recorded increase in the past 43 years for any adolescent substance use outcome in the United States [28<sup>11</sup>]. Epidemiological survey data indicate a year-by-year increase and doubling of exposure within the previous 30 days, 12 months and even daily nicotine vaping from 2017 to 2019 in youth in the 8th grade and older [29]. Additionally, alongside an increase in vaping rates in this demographic, we are now seeing an associated increase in cigarette smoking (32–37%) in youth 16–19 years of age [30,31]. This fact does not seem lost on big tobacco. The makers of Marlboro cigarettes, Altria, invested 12.8 billion dollars in JUUL in December 2018 [32].

In a very short amount of time, E cigarettes and the vaping epidemic have effectively reversed five decades of decreasing nicotine use among youth [28<sup>11</sup>,33].

E cigarettes were initially marketed as a smoking cessation tool for adults (despite not being FDA approved for this indication) [34,35]; however, this is not the primary reason for use among adolescents [36]. Vaping in teens is more commonly a form of experimentation or for taste and entertainment [36]. The attraction is related to sleek design, user-friendly functions, social acceptability, perception of safety and importantly, desirable flavors [14<sup>11</sup>,37–39]. A study published in *Pediatrics* in 2019 found that the majority of high school students in California who vaped preferentially used nontraditional flavors (fruit, candy, sweet or dessert) at 93.8%, as compared to traditional flavors (menthol, tobacco, mint and unflavored) at 6.2%. Furthermore, the use of nontraditional flavors was positively associated with vaping continuation at 6 months [14<sup>11</sup>]. E cigarette companies have widely marketed the flavoring, sleek design and social acceptability via multiple media channels involving social media platforms, online availability, magazine, television and radio advertising, as well as promotional activities and celebrity sponsorship [26]. Similar strategies have been used by tobacco companies prior to the regulation and limitation of their advertising directly to youth.

## REGULATION

The impact of E cigarettes on public health has not been clear, making jurisdictional regulations challenging. With health risks now appreciated to a much greater extent, the regulatory landscape has recently in response been very active. An analysis of global regulation within the industry in 2014–2016 revealed 68 countries during that time period regulating E cigarettes; the most common forms of regulation included sale bans, use restrictions (vape-free public places), age-of-purchase requirements and advertising and promotion bans. Few countries applied a tax to E cigarettes, and many countries were extrapolating legislation not initially written for E cigarettes [40].

In North America, CDC raised the alarm in 2013 of the potential addictiveness and unknown health effects of E cigarettes especially among youth [41], and in 2016 a proposal was taken to President Obama's administration to ban flavored E cigarettes with special concern for increasing use in adolescents. Under intense lobbying from E cigarette and tobacco industries, the proposal was rejected and flavored E cigarettes remained on the market [42]. In



2016, the FDA gained regulation over E cigarettes, and measures and enforcements subsequently were put into place including nicotine addictiveness warning statements on all product packages and advertisements. However, prior to 2016, these products were indeed marketed toward and directly sold to youth less than 18 years old [26,43].

E cigarettes containing nicotine became legal in Canada with the passage of Bill S-5 in May 2018. Regulation is only now in 2019 being actively considered and implemented to curb the negative impact on youth, and currently varies by province or territory, although a recent federal proposal by Health Canada announcing new regulations prohibiting the promotion, advertising and sale of vaping products anywhere they can be seen or heard by youth (public spaces, convenience stores or online) is in a period of public consultation. Additional measures include mandatory health warnings on vaping product packaging, child resistant packaging and potential limits on nicotine content (e.g. 20 mg/ml as regulated by the European Union instead of the currently available 59 mg/ml) to ensure that vaping products are not toxic to children if unintentionally ingested. Some regulation addressing marketing of candy flavors to youth already exists, but what is missing as of yet is a federal ban on the sale of flavored E cigarettes. Similarly, in the United States, it is only recently that new regulations have been imposed. In December of 2019, the age of legal tobacco consumption was raised to 21 years, and certain flavors outside of tobacco and menthol banned in cartridge-based E cigarettes.

Although there is regulatory tension in public health strategy between E cigarettes as a potential harm reduction tool for established smokers and a desire for complete abstinence for children and youth, our focus and lens is on protecting young people from inadvertent lifetime addiction and negative health consequences. Regulation thus needs to be thoughtful, logical, but aggressive to reverse course on an epidemic that got away from society. Curbing the normalization of tobacco products again in society through prohibiting marketing and advertising to youth and at point of sale, restricting these products to specialty stores with age limits strictly enforced, reducing online sales, ensuring similar health warnings are clearly present and that all products have child resistant packaging, and banning youth-friendly flavoring are essential elements to reducing uptake and potential injury in children and youth. Governments should proceed both with taxation, in line with other tobacco products, and regulating nicotine concentrations in these products to not exceed 20 mg/ml. Investments

in youth education campaigns in both the United States and Canada have been influential in changing attitudes in youth, and alongside essential regulatory efforts, public education efforts should continue. Surveillance and dedicated research funding must also be allocated to allow for better understanding of both potential benefits in smoking cessation and short-term and long-term risks to individuals and the public at large.

## CONCLUSION

In a very short period, the epidemic use of E cigarettes and the practice of vaping, not only nicotine but now an expanded profile of THC and hashish, has rapidly become a critical public health issue for North American youth. E cigarettes can have severe short-term health risks, and children and youth are particularly vulnerable to the effects of nicotine and other substances, with long-term risks not yet fully known. Regulation in North America in the last decade has been reactionary as opposed to preventive, and young populations have suffered for it. Thoughtful but aggressive regulation must now be a priority to limit and reverse the damage that has already been done.

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## Conflicts of interest

*There are no conflicts of interest.*

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- of special interest
- of outstanding interest

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