

# A Public Health Crisis: Electronic Cigarettes, Vape, and JUUL

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Electronic cigarettes (e-cigarettes) and vape devices have rapidly become the most common tobacco products used by youth, driven in large part by marketing and advertising by e-cigarette companies. There is substantial evidence that adolescent e-cigarette use leads to use of combustible tobacco products. E-cigarette companies commonly advertise that e-cigarettes contain nicotine, flavoring chemicals, and humectants (propylene glycol and/or vegetable glycerin), but toxicants, ultrafine particles, and carcinogens have also been found in e-cigarette solutions and emissions, many of which are known to cause adverse health effects. Most major e-cigarette brands are owned by big tobacco companies that use similar marketing and advertising strategies to attract youth users as they did with traditional tobacco products. In this review, we provide an overview of e-cigarettes and vape devices with an emphasis on the impact for the pediatric population. We describe the vast array of e-cigarette devices and solutions, concern for nicotine addiction, and the scientific background on the known health harms. There are accompanying visual depictions to assist in identifying these products, including newer e-cigarette products and JUUL. Because current federal regulations are insufficient to protect youth from e-cigarette use, exposure, and nicotine addiction, there are recommendations for pediatricians and pediatric health care providers to counsel and advocate for a tobacco-free lifestyle for patients and families.

## DEFINITIONS

**Combustible tobacco product:** A tobacco product that involves the burning of the tobacco leaf for inhalation. This includes conventional cigarettes, cigars, cigarillos, hookahs, and pipe tobacco.

**Electronic cigarette (e-cigarette) aerosol:** Although often referred to as vapor, the emission of an e-cigarette is more accurately described as an aerosol, a suspension of particles in gas.

**Secondhand aerosol:** The emissions of e-cigarettes that nonusing bystanders are exposed to, mainly from what is exhaled by the user during use of the product.

**Thirdhand aerosol:** The nicotine and toxicants that are present in the environment, mainly on surfaces, from the emissions of an e-cigarette after use.

**JUUL:** A brand name of an e-cigarette that is shaped like a flash drive, has prefilled cartridges (“pods”) with solutions that contain a high concentration of nicotine, and is available in many youth-appearing flavors.

E-cigarettes and vape devices are handheld devices designed to deliver emissions for inhalation by heating a solution that commonly contains nicotine, a humectant, and flavoring chemicals. For the purpose of this review, the term “e-cigarette” will be

## abstract

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**DOI:** <https://doi.org/10.1542/peds.2018-2741>

Accepted for publication Jan 7, 2019

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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**FINANCIAL DISCLOSURE:** The authors have indicated they have no financial relationships relevant to this article to disclose.

**FUNDING:** No external funding.

**POTENTIAL CONFLICT OF INTEREST:** The authors have indicated they have no potential conflicts of interest to disclose.

**To cite:** Walley SC, Wilson KM, Winickoff JP, et al. A Public Health Crisis: Electronic Cigarettes, Vape, and JUUL. *Pediatrics*. 2019;143(6):e20182741

used; however, these devices are more commonly referred to by the public and users as vapes, pod systems, mods, and tanks as well as by brand names such as JUUL. In the scientific literature, e-cigarettes are commonly referred to as electronic nicotine delivery systems. Because they commonly contain nicotine, which is derived from the tobacco plant, e-cigarettes are tobacco products.<sup>1</sup>

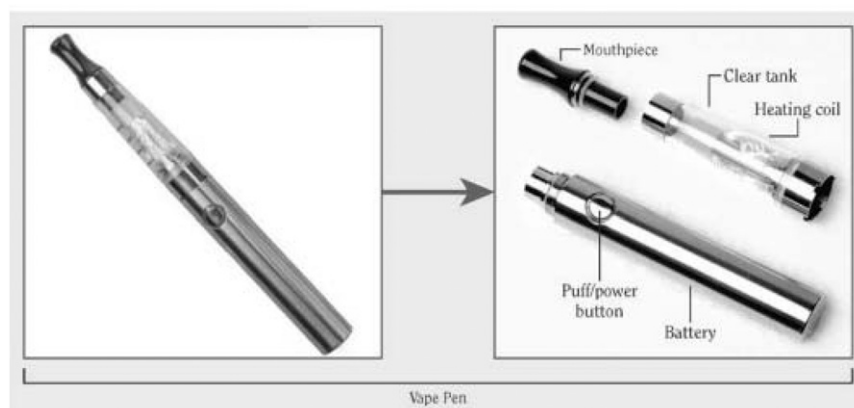
The awareness, marketing, advertising, and use of e-cigarettes have dramatically increased since their introduction into the US marketplace. The e-cigarette was introduced into the US market from China around 2006, where it was patented as an “electronic atomizing cigarette.”<sup>2,3</sup> By 2010, there were several brands of e-cigarettes that were sold in US markets.<sup>2</sup> In 2011, e-cigarettes were added to the National Youth Tobacco Survey (NYTS) on tobacco-product use, and since 2014, the e-cigarette has been the most frequently used tobacco product by youth.<sup>4</sup>

## E-CIGARETTE DEVICES AND CONSTITUENTS

### Basic Operation

Part of the difficulty in the research and regulation of e-cigarettes is the diversity and rapid change in nomenclature, design, and technology, not only of the devices but also in the e-cigarette solution. Despite this variation, the majority of these products have similar design characteristics, which include the following components (Fig 1):

1. a mouthpiece;
2. a sensor or user-actuated button to activate the heating coil (seen in Fig 1);
3. a battery;
4. a heating coil or atomizer; and
5. a reservoir or tank.



**FIGURE 1**

E-cigarette components. (Adapted from *E-Cigarette Use Among Youth and Young Adults: A Report of the Surgeon General*. US Department of Health and Human Services; Centers for Disease Control and Prevention; National Center for Chronic Disease Prevention and Health Promotion; Office on Smoking and Health. Atlanta, GA: US Department of Health and Human Services; 2016:12.)

When a user inhales from the mouthpiece, the heating coil is activated to aerosolize the e-cigarette solution to form an emission, which is best described as an aerosol but is commonly called a vapor. A video clip showing the use of an e-cigarette can be found online.<sup>5</sup>

There have been substantial changes and evolution of e-cigarettes, and thus e-cigarette devices have often been described as first-, second-, and



**FIGURE 2**

E-cigarette design variability. Seen on the far left is a conventional cigarette. The earlier e-cigarettes (first generation) have a similar shape as a conventional cigarette (second, third, and fourth from the left). The second-generation e-cigarettes (fifth and sixth from the left) have refillable clear reservoirs for the e-liquid and are often known as vape pens. The third-generation e-cigarettes (far right) often have the ability to modify wattage and voltage and are thus known as mods.

third-generation products to assist in describing their wide variability (Fig 2). The first-generation e-cigarette products usually have the appearance of a cigarette and are referred to as “cigalikes.” First-generation e-cigarettes are often disposable or have a reloadable cartridge for repeated uses. Second-generation e-cigarettes are known as vapes or vape pens and have a refillable reservoir for the electronic cigarette liquid (e-liquid). Third-generation e-cigarettes are frequently referred to as “mods” or tank systems because the wattage and voltage can be modified. More recently, there has been a wave of products that bear no resemblance to traditional cigarettes or even previous generations of e-cigarettes, which, for purposes of this review, will be referred to as fourth-generation e-cigarettes. Fourth-generation products are sold under the names JUUL (Fig 3), Suorin, and SMPO.

### E-cigarette Solution

E-cigarette solutions, often known as e-juice or e-liquid, are even more diverse than the devices. The solutions are commonly advertised as containing 3 types of chemicals: a humectant, nicotine, and flavors.<sup>2</sup> The 2 humectants used most often



**FIGURE 3**  
JUUL and JUUL pods.

are propylene glycol (PG) and vegetable glycerin; both are generally recognized as safe for ingestion, but there is little evidence about their safety for long-term inhalation. The majority of e-cigarette solutions are advertised as containing nicotine; the nicotine concentration can vary, both in the reported concentration and in the actual concentration as measured by gas chromatography.<sup>6</sup> There are also some e-liquids that are advertised as 0% nicotine. E-cigarette solutions are often labeled with concentrations between 0 and 24 mg/mL of nicotine, but more recently, the e-cigarette brand JUUL has an e-cigarette solution containing benzoic acid and a much higher advertised nicotine concentration of 59 mg/mL.<sup>7</sup> Typical nicotine absorption from a conventional cigarette is 1 mg (range 0.3–2 mg), with blood nicotine levels ranging from an average of 15 to 30 ng/mL.<sup>8,9</sup>

Most brands of e-cigarette solutions are available in a variety of youth-appealing flavors ranging from fruits, desserts, candy, and soda to traditional tobacco. Menthol is a common compound found in both mint- and tobacco-flavored e-cigarette solutions.<sup>6</sup> An analysis of coffee- and chocolate-flavored e-cigarette solutions revealed that 42% of coffee-flavored liquids and 50% of chocolate-flavored liquids contained detectable caffeine levels.<sup>10</sup>

Glucose, fructose, and sucrose levels were also detected in 22% to 53% of a set of e-liquid samples.<sup>11</sup> Other substances, such as marijuana and methamphetamine, can also be vaped from some e-cigarette devices.<sup>12</sup>

### JUUL and Other Vaping Products

JUUL is a brand of e-cigarette that has recently received significant media attention because of its rapid uptake by adolescents.<sup>13</sup> Part of the appeal of JUUL is the small sleek shape and the ability to use the device surreptitiously. The JUUL device looks like a flash drive (Fig 3) and is rechargeable via a USB port.<sup>7</sup> Educators report that teenagers covertly use the product during school, even in the classroom.<sup>13</sup> Rather than vaping, JUUL users are said to be “JUULing,” and the Internet is full of videos of adolescents using JUUL. The device uses prefilled cartridges called pods that contain 0.7 mL of solution unique to JUUL.<sup>7</sup> In addition to PG and glycerol, the pod is advertised to contain benzoic acid (a naturally occurring acid found in the tobacco plant) and nicotine.<sup>7</sup> As of August 2018, JUUL advertises pods with 2 nicotine concentrations of 5% (59 mg/mL) and 3% (35 mg/mL).<sup>7</sup> Each pod is marketed as equivalent to ~1 pack of cigarettes (ie, 200 puffs), and pods are sold in multiple youth-appealing flavors, including mango, fruit medley, crème (brûlée), mint, and cucumber.

The evidence of JUUL’s recent increase in popularity is demonstrated by sales data that revealed that in August 2018, JUUL sales were 72.1% of the market share of the US e-cigarette market, compared with 13.6% in the first quarter of 2017.<sup>14,15</sup> A JUUL starter kit can be purchased for \$49.99, which includes the device with a charging dock and 4 JUUL pods.<sup>16</sup>

Additional JUUL pods can be purchased in packs of 4 for \$15.99.<sup>17</sup> The JUUL website reports their mission is to “improve the lives of the world’s one billion adult smokers by eliminating cigarettes.”<sup>18</sup> They state on their Web site that they do not sell to youth <21 years of age; however, previous marketing campaigns were clearly targeted at a youthful demographic, and the flavors are appealing to youth. In December 2018, JUUL sold a 35% stake to the tobacco company Altria, formerly known as Philip Morris, for \$13 billion, evoking additional concerns about the company’s strategy to address use by teenagers.<sup>19</sup>

### MARKETING, ADVERTISING, AND SALES

The tobacco industry has long been known to use deceptive marketing and advertising to target certain populations, including youth and minorities.<sup>20</sup> Although product marketing refers to a company’s strategy to brand their product, the term “promotion” refers to advertising in mainstream media, including the Internet, television, magazines, social media channels, direct-to-consumer marketing, and point-of-sale advertisements.<sup>2</sup> Point of sale refers to advertisements that are visible around the time of purchase and accounts for the majority of the advertising dollars tobacco companies spend.<sup>21</sup> It is well established that marketing and promotional activities by tobacco companies increase youth and young adult tobacco initiation and usage.<sup>22</sup> Television advertisements for cigarettes were banned in 1971; however, 78% of middle and high school students in 2016 had seen a television advertisement for e-cigarettes.<sup>23</sup> Studies have revealed that youth who are exposed to advertisements are more likely to use e-cigarettes.<sup>24–26</sup>

E-cigarettes are sold in multiple venues, including in vape shops, grocery and convenience stores, gas stations, and on the Internet.<sup>1</sup> The majority of underage sales of tobacco products occur in the retail environment, in which enforcement of age at purchase is largely the responsibility of the retailer.<sup>27,28</sup> Internet sales are also a major concern regarding youth access to e-cigarettes because of the difficulty with regulation and the number of online retailers.<sup>29</sup> In a review of online e-cigarette brands, 433 distinct sites were found, 12 of which were owned by tobacco companies.<sup>30</sup>

### EPIDEMIOLOGY OF E-CIGARETTE USE

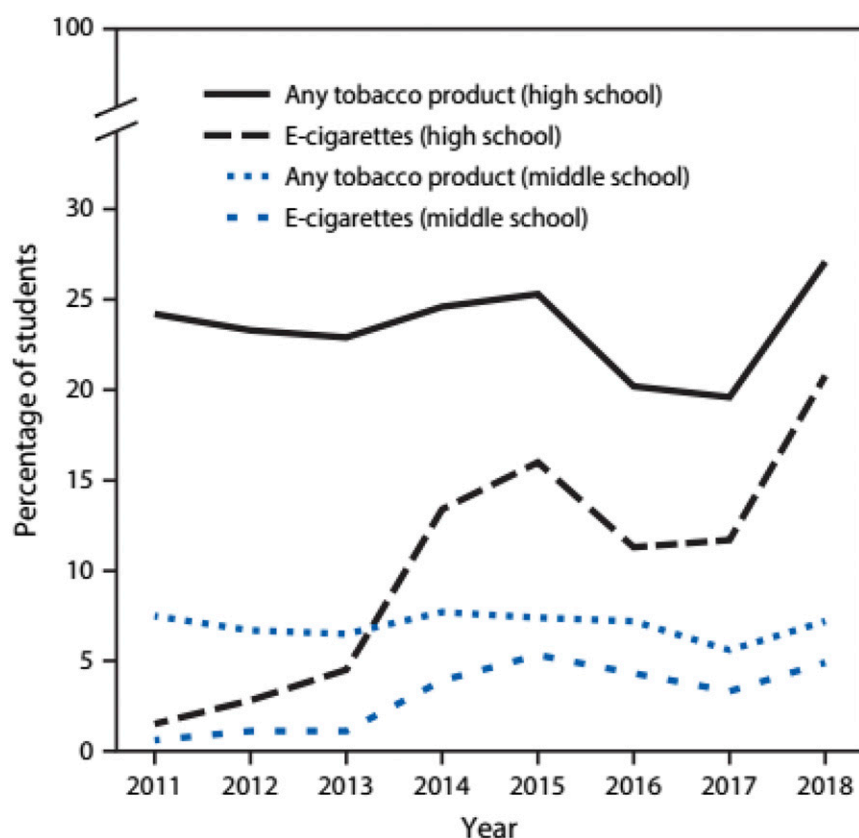
The ubiquitous marketing, promotion, and sales of e-cigarettes have been

effective, with dramatic increases in youth e-cigarette use.<sup>1</sup> Between 2011 and 2015, the NYTS revealed that US current use among high school students (use on  $\geq 1$  days during the past 30 days) increased 966% from 1.5% to 16% (Fig 4).<sup>4,31</sup> After a 2-year period between 2015 and 2017 in which there was an overall decline in youth use, there was a sharp 78% increase in current use among high school students to 20.8% from 2017 to 2018.<sup>32</sup> Accounting for a current use among middle school students of 4.9%, this represents 3.62 million youth e-cigarette users.<sup>32</sup> Another national survey, Monitoring the Future (MTF) has trended youth substance use over the past 44 years, including e-cigarette use since 2015.<sup>33</sup> The MTF has revealed similar trends in e-cigarette use, including

a sharp increase in 2018, with 25% of 12th-graders and 20.3% of 10th-graders using vaped nicotine or flavoring (compared with 15.2% and 12%, respectively, in 2017).<sup>34</sup> The increase in e-cigarette use among 10th- and 12th-graders from 2017 to 2018 represents the largest increase of any substance the MTF survey has recorded in its 44 years.<sup>34</sup> Despite these dramatic increases, many experts express concern that e-cigarette use may be underestimated because of survey limitations.

Survey results have also revealed that many youth use e-cigarettes with other tobacco products, which is known as dual use. During the period of 2015–2017, the NYTS revealed that 76.7% of middle and high school students who used e-cigarettes used another tobacco product.<sup>35</sup> The Youth Risk Behavior Survey from 2015 revealed that whereas 15.8% of high school students used only e-cigarettes, 7.5% were dual users of e-cigarettes and conventional cigarettes.<sup>36</sup>

Adult US patterns of e-cigarette and tobacco use are different because the conventional cigarette remains the most common tobacco product used among those aged 18 years and older.<sup>37</sup> On the basis of the 2017 National Health Interview Survey (NHIS), current adult use of e-cigarettes is 2.8%, whereas use of cigarettes is 14%.<sup>37</sup> However, there are statistically higher rates of use depending on age and other tobacco use. Among younger age groups in the NHIS, adults aged 18 to 24 years had the highest rates of e-cigarette use, with 5.2% reporting “every day” or “some days” use.<sup>38</sup> The MTF survey in 2017 revealed higher rates of current e-cigarette use at 11.3% among younger adults (ages 19–30 years), with use among 19- to 20-year-olds at 13%.<sup>33</sup> However, the highest rates, of adult e-cigarette use are among current and former working adult cigarette users, with rates of 15.9%



**FIGURE 4**

Percentage of middle and high school students who currently use e-cigarettes and any tobacco-products based on NYTS 2011–2018. (Reprinted from Cullen KA, Ambrose BK, Gentzke AS, Apelberg BJ, Jamal A, King BA. Notes from the field: use of electronic cigarettes and any tobacco product among middle and high school students - United States, 2011–2018. *MMWR Morb Mortal Wkly Rep*. 2018;67(45):1276.)



and 22%, respectively, in the NHIS.<sup>38,39</sup> The Population Assessment of Tobacco and Health (PATH) study revealed that 5.5% of adults were current e-cigarette users in 2013–2014, with 70% of e-cigarette users reporting dual use with cigarettes.<sup>40</sup>

### HEALTH HARMS OF E-CIGARETTE USE

More than 50 years after the initial Surgeon General landmark report, “Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Services,” and 30 years after “The Health Consequences of Involuntary Smoking,” there continue to be new discoveries on health harms related to conventional cigarettes and traditional tobacco products. Because e-cigarettes have only been marketed for ~10 years and because the products are rapidly changing, scientific data are limited and will continue to emerge. Because e-cigarette solutions and emissions have been shown to contain nicotine and many of the same harmful toxicants and carcinogens as cigarettes, it is reasonable to assume that there is the potential for similar health effects for e-cigarette use, particularly with emerging data of tobacco toxicant exposure found among e-cigarette users. A population-based adult cohort study revealed that exclusive e-cigarette users had higher urine concentrations of nicotine, metals, volatile organic compounds (VOCs), and tobacco-specific nitrosamines compared with nontobacco users.<sup>41</sup> In addition, this same study showed that e-cigarette users had concentrations of metals and VOCs (toluene, benzene, and carbon disulfide) comparable with those of cigarette smokers, with dual users having the highest levels of nicotine and other tobacco biomarkers, metals, and VOCs.<sup>41</sup>

In the National Academy of Sciences, Engineering, and Medicine (NAS)

report “The Public Health Consequences of E-Cigarettes,” it was concluded that there is not adequate research to predict long-term health outcomes but that there is sufficient evidence that use of e-cigarettes can cause acute endothelial dysfunction, oxidative stress, symptoms of dependence, and an increase in heart rate and that chemicals in e-cigarettes can cause DNA damage and mutagenesis.<sup>3</sup> There is evidence of an increase in blood pressure (systolic and diastolic) after use of nicotine-containing e-cigarettes.<sup>3</sup>

In addition, there is also a growing body of evidence of the respiratory effects of e-cigarette use for the e-cigarette user, particularly for adolescents with asthma.<sup>42–44</sup> The NAS report concludes that “[t]here is moderate evidence for increased cough and wheeze in adolescents who use e-cigarettes and an association with e-cigarette use and an increase in asthma exacerbations.”<sup>3</sup>

The comparison, when considering potential health effects for youth and adults who do not use tobacco, should always be clean air, not cigarette use. Thus, the guiding principle should be that e-cigarette use is harmful for the short- and long-term health of youth until proven otherwise. Further studies are needed to better characterize the health effects of e-cigarettes on youth and adults.

### Nicotine: Health Effects and Addiction Potential

Specific to youth, nicotine addiction and dependence leading to lifelong tobacco use is a major concern when considering e-cigarette use. Ninety percent of adult cigarette smokers began smoking before the age of 18 years, and the adolescent brain is more susceptible to nicotine addiction even with intermittent exposure.<sup>22</sup> Nicotine is an ingredient in most e-cigarette solutions and is the primary ingredient in tobacco

products that causes addiction.<sup>45</sup> Nicotine’s primary psychoactive actions are related to its binding to the nicotine cholinergic receptor in the brain to release dopamine, which is part of the pathway involved in drug-induced reward.<sup>7,46</sup> Nicotine addiction is an adaption to nicotine exposure over time, and thus the high concentrations of nicotine in e-cigarettes are of major concern. Studies of e-cigarette use have revealed that, depending on duration of use and user puffing topography, serum levels of nicotine can be as high with e-cigarette use as with use of a conventional cigarette.<sup>3</sup> In 1 study, the urinary cotinine concentrations (a biomarker for nicotine exposure) among adolescents using JUUL was even higher than the urinary cotinine concentrations of those who smoked conventional cigarettes.<sup>47</sup> FDA-approved nicotine-replacement therapy increases serum nicotine concentrations gradually and at lower levels than cigarettes, thus decreasing addiction potential.<sup>48</sup>

There are concerns for adverse health effects of nicotine, although the majority of death and disease from tobacco products are secondary to toxicants other than nicotine.<sup>46,49</sup> Studies support that nicotine dependence affects the areas of the brain that control executive function, memory, and mood, and nicotine has been shown to have neurodevelopmental effects in children with prenatal cigarette exposure.<sup>49</sup> In the NAS report, it was concluded that “exposure to nicotine from e-cigarettes likely elevates the risk in people with preexisting cardiovascular disease(s), but the risk in people without cardiovascular disease(s) is uncertain.”<sup>3</sup> It was also concluded that there is plausibility that nicotine can act as a tumor promoter, but the evidence suggests it is unlikely to increase the incidence of cancers.<sup>3</sup>

### **Youth Progression to Conventional Cigarettes, Other Substances of Abuse, and Risky Behaviors**

The Surgeon General estimates that 5.6 million of today's youth will die prematurely of a smoking-related illness.<sup>46</sup> One of the most concerning aspects of youth use of e-cigarettes is the well-described trajectory to use of conventional cigarettes. In a meta-analysis of 9 studies by Soneji et al,<sup>50,51</sup> the authors concluded that adolescents who use e-cigarettes are 3.5 times more likely to initiate conventional cigarette smoking than those who do not use e-cigarettes. Two additional studies published in 2018 from the PATH survey revealed that the odds of 30-day cigarette use at the 1-year follow-up was almost twice as high (odds ratio 1.87) for youth who had "ever used" e-cigarettes at baseline, and e-cigarette use was associated with current established cigarette smoking.<sup>52,53</sup>

Multiple studies have revealed an association between adolescent e-cigarette use and other substance use, including alcohol, marijuana, and amphetamines, as well as other risky behaviors, which are consistently greatest among dual users of e-cigarettes and conventional cigarettes.<sup>36,54,55</sup> Risky behaviors include violent behaviors (fighting and attempting suicide), sexual risk behaviors (current sexual activity and lifetime partners), and school-related behaviors (truancy and lower grade point average). The PATH survey also revealed longitudinally that e-cigarette use was associated with subsequent youth use of other substances of abuse.<sup>56</sup> This association was strongest for marijuana and nonprescribed Ritalin and/or Adderall but was noted for alcohol and all other drugs (excluding nonprescribed painkillers and/or sedatives).<sup>56</sup>

### **PUBLIC HEALTH IMPLICATIONS**

#### **Renormalization of Tobacco-Product Use**

Adult and youth use of tobacco products has gradually decreased over the past 50 years, in part related to a culture that has denormalized the use of traditional tobacco products such as conventional cigarettes. Many youth do not recognize that e-cigarettes contain nicotine and therefore may not understand the addictive potential of e-cigarettes.<sup>57,58</sup> A quick Internet search reveals a myriad of videos demonstrating the ways e-cigarettes are used by adolescents and young adults. "Cloud chasing," "stealth vaping," and "dripping" are popular terms. Dripping involves dripping the e-cigarette solution directly onto the heating coil to inhale the vapor directly. One in 4 adolescents reported using their e-cigarettes for dripping.<sup>59</sup>

#### **E-cigarette Secondhand and Thirdhand Aerosol**

The secondhand aerosol emitted by e-cigarettes (known commonly as vapor) into the environment is different from that of conventional cigarettes because it is directly inhaled from the device without the generation of sidestream smoke. Thus, the aerosol emitted into the environment from e-cigarettes is almost 100% mainstream. Additionally, the composition of aerosols emitted from combustible and noncombustible devices differs. Secondhand tobacco smoke contains solid and semisolid materials, whereas e-cigarette aerosol is mostly composed of small liquid droplets.<sup>3</sup> Secondhand aerosol from e-cigarettes contains significantly different levels of harmful chemicals depending on the device and the voltage used as well as the vaping patterns.<sup>60</sup> Thirdhand aerosol is the nicotine and toxicants that are present in the environment and surfaces after the e-cigarette has been used.<sup>1</sup>

Researchers have disproved claims by e-cigarette manufacturers that e-cigarette aerosols are only water vapor, glycerol, and PG and can be used safely in all environments. Investigators have shown that indoor nicotine, fine and ultrafine particulate matter, polycyclic aromatic hydrocarbons, metals (aluminum), and some volatile inorganic compounds rise after vaping occurs.<sup>61–63</sup> Particulate matter at vaping conventions reaches a level 12 times higher than that of the US Environmental Protection Agency 24-hour standard.<sup>64</sup> Airborne particulate matter and nicotine levels at vaping conventions were comparable with those found at bars and nightclubs where combustible smoking is allowed. In addition, volatile inorganic compound and carbon dioxide levels were markedly elevated. Thirdhand aerosol exposure to nicotine has also been identified after vaping with the accumulation of nicotine on surfaces and clothing, measured by wipe sampling after the vaping session. Surface nicotine on clothing was measurable both on the person who vaped and on nonusers after the vaping session.<sup>63</sup>

It is of particular concern that both fine and ultrafine particulate matter can be found in indoor air after a vaping session because these particles can be inhaled into the lungs and can enter the systemic circulation, leading to inflammation and potential cardiovascular disease. However, information on health risks as a result of exposure to e-cigarette emissions is limited. Using an animal model of e-cigarette exposure, McGrath-Morrow et al<sup>65</sup> demonstrated that neonatal mice that were exposed to e-cigarette vapor (both PG alone and with nicotine) had impaired growth compared with control mice. Additionally, mice exposed to e-cigarette vapor showed poor lung development, with decreased development of alveoli.<sup>65</sup>

In the NAS report, it was concluded that “e-cigarettes can contribute to substantial air pollution, especially in places with large number of e-cigarette users”; it was additionally stated that “[t]here is conclusive evidence that e-cigarette use increases airborne concentrations of particulate matter and nicotine in indoor environments compared with background levels.”<sup>3</sup>

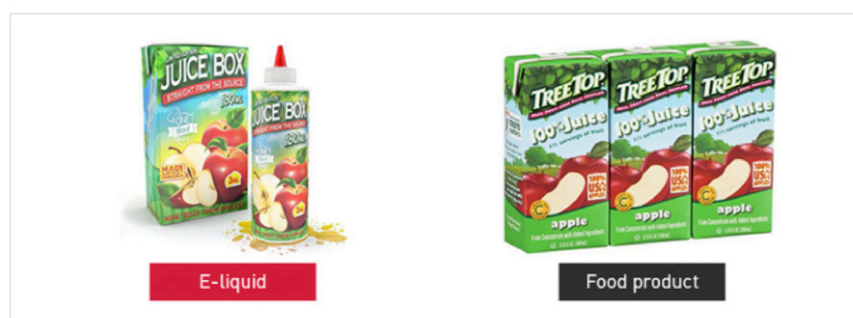
### Poisonings and Other Unintended Injuries

Injuries from both unintentional exposure to e-cigarette solutions as well as to the e-cigarette device have been reported. E-cigarette liquid nicotine exposures, mainly from ingestions, have increased by 1085% from 2012 to 2016, although exposures have decreased from their highest rate in 2015.<sup>66</sup> This decrease may be, in part, related to education as well as the Child Nicotine Poisoning Prevention Act of 2015, which required that nicotine-containing e-cigarette solutions be sold in child-resistant packaging. The high concentrations of nicotine in some e-cigarette solutions can cause health effects for children at small volumes and have resulted in 1 child death.<sup>1</sup> The lithium batteries used in many e-cigarette devices can explode, and the explosions have resulted in severe burns and fires.<sup>3</sup>

### E-cigarettes Are Not FDA-Approved for Adult Smoking Cessation

As of this publication date, there are no e-cigarette products that are FDA-approved smoking cessation treatments. A recent meta-analysis of 26 studies in real-world settings and clinical trials revealed that adult smokers who use e-cigarettes for smoking cessation are 27% less likely to stop smoking than smokers who do not use e-cigarettes.<sup>67</sup> The NAS concluded that there are potential health benefits for conventional cigarette users who completely switch to e-cigarettes and that “there is limited evidence that e-cigarettes

#### One Mad Hit Juice Box



#### Candy King Batch/Candy King Sour Worms



**FIGURE 5**

FDA warning of e-cigarette products with labels similar to juice and candy. (Adapted from US Food and Drug Administration. E-liquids misleadingly labeled or advertised as food products. Available at: <https://www.fda.gov/TobaccoProducts/NewsEvents/ucm605729.htm>. Accessed November 28, 2018.)

may be effective aids to promote smoking cessation.”<sup>3</sup> The American Academy of Pediatrics (AAP) and other medical organizations recommend that adults dependent on tobacco use evidence-based treatments, which include FDA-approved pharmacotherapy.<sup>68</sup>

### FEDERAL AND STATE REGULATION

In 2016, with its “deeming rule,” the FDA extended its authority to e-cigarettes and other tobacco products, including cigars.<sup>69</sup> As of this publication date, aspects of the deeming rule that have been implemented include prohibiting sales to children <18 years of age and adding health warning labels. Implementation of other regulations under the deeming rule has been suspended, including premarket review of new e-cigarette solutions, and would not take full effect until

2022. The deeming rule does not address marketing, flavors, or regulation of the e-cigarette devices nor regulate e-cigarette batteries. There are an estimated 15 000 e-cigarette flavors, including products with labels enticing to children and adolescents that imitate cookies, whipped cream, alcoholic beverages, and other dessert flavors. Products such as One Mad Hit Juice Box imitate a juice box, with labels that contain such statements as “A Juicebox a Day Keeps the Doctor Away,” and the Candy King Batch and Candy King Sour Worms label imitates that of the popular the Sour Patch Kids candy (Fig 5). Flavors in tobacco products have been known for decades to promote youth use, and thus characterizing flavors (with the exception of menthol) were banned from conventional cigarettes in 2009 by the Family Smoking Prevention and Tobacco Control Act.

In December 2018, in part because of the rapid rise in use from 2017 to 2018, the US Surgeon General called youth e-cigarette use an epidemic and called for action to protect child health. This was preceded in 2018 by the FDA announcing efforts to restrict youth access to e-cigarettes through efforts targeted at retailers and online sales of e-cigarettes as well as some restrictions of flavored tobacco products. These actions are being followed closely by the AAP and other child health advocates because the rapid rise in youth use has revealed that previous policies were insufficient. Many states and local governments have implemented ordinances that include e-cigarettes in comprehensive smoke and tobacco bans. In addition, 6 states and hundreds of cities at the time of this publication have implemented Tobacco 21 (T21), which refers to raising the minimum age of sale of tobacco products, including e-cigarettes, to 21 years of age.<sup>70</sup>

## RECOMMENDATIONS FOR PEDIATRICIANS AND PEDIATRIC HEALTH CARE WORKERS

### Clinical Recommendations

The AAP policy statement “Electronic Nicotine Delivery Systems” recommends that pediatric health care providers screen for e-cigarette use when screening for tobacco use and tobacco-smoke exposure.<sup>1</sup> For youth, prevention is crucial with strong messages to avoid tobacco use (including e-cigarettes), and for youth using tobacco products, clinicians should recommend evidence-based tobacco-use treatment.<sup>68</sup> For parents and caregivers who use tobacco, the AAP clinical practice policy recommends that pediatricians offer tobacco-use treatment to address tobacco use and eliminate tobacco-smoke exposure.<sup>68</sup>

## Public Policy Recommendations

In this section, we present concrete objectives for advocacy that may help to control the e-cigarette public health crisis.

### Objective 1

Support strong T21 legislation, which has the potential to severely limit tobacco-product use (including e-cigarettes) in adolescents because almost no high schoolers will be of legal age. Building partnerships among pediatricians, community members, youth leaders, tobacco-control groups, departments of public health, and local politicians has shown promise in building the political will needed to disseminate, improve, and enforce T21 regulations.

### Objective 2

Develop free continuing medical education programming for clinicians to ensure that child health care providers have the tools and strategies to inoculate against corporate marketing that attracts youth to use nicotine products as early as middle school.

### Objective 3

Conduct research to track and evaluate e-cigarette use and prevention strategies at the middle school, high school, and college campuses where e-cigarette use propagates. Conduct research on policy and regulatory enforcement strategies to prevent youth access to e-cigarette products in the retail environment.

### Objective 4

Research and disseminate effective tobacco-control messaging and educational content for parents, teachers, and students. Develop treatment strategies and programs for the adolescents who are current users of e-cigarettes and JUUL-type products. Currently, no evidence-based programs exist to help

adolescents and young adults quit e-cigarette addiction.

### Objective 5

Increase tobacco retail-licensing fees to help cover the cost of enforcement. Increase taxes on tobacco products; adolescents are more price sensitive, so increasing prices will decrease adolescent initiation and subsequent addiction.

### Objective 6

Ban all flavored tobacco products, including mint and menthol.

## CONCLUSIONS

The e-cigarette is the most common tobacco product used by youth, exposing users to nicotine, toxicants, and ultrafine particles, which have the potential to lead to nicotine addiction and harmful health effects. In 2018, e-cigarettes were used by 3.6 million middle and high school students, and the popularity of newer e-cigarette brands, such as JUUL, with sleek designs and higher nicotine concentrations is a public health crisis.

## ABBREVIATIONS

AAP: American Academy of Pediatrics  
e-cigarette: electronic cigarette  
e-liquid: electronic cigarette liquid  
FDA: Food and Drug Administration  
MTF: Monitoring the Future  
NAS: National Academy of Sciences, Engineering, and Medicine  
NHIS: National Health Interview Survey  
NYTS: National Youth Tobacco Survey  
PATH: Population Assessment of Tobacco and Health  
PG: propylene glycol  
T21: Tobacco 21  
VOC: volatile organic compound



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