



# E-Cigarettes and Similar Devices

Brian P. Jenssen, MD, MSHP, FAAP,<sup>a</sup> Susan C. Walley, MD, FAAP,<sup>b</sup> SECTION ON TOBACCO CONTROL

Electronic cigarettes (e-cigarettes) are the most commonly used tobacco product among youth. The 2016 US Surgeon General's Report on e-cigarette use among youth and young adults concluded that e-cigarettes are unsafe for children and adolescents. Furthermore, strong and consistent evidence finds that children and adolescents who use e-cigarettes are significantly more likely to go on to use traditional cigarettes—a product that kills half its long-term users. E-cigarette manufacturers target children with enticing candy and fruit flavors and use marketing strategies that have been previously successful with traditional cigarettes to attract youth to these products. Numerous toxicants and carcinogens have been found in e-cigarette solutions. Nonusers are involuntarily exposed to the emissions of these devices with secondhand and thirdhand aerosol. To prevent children, adolescents, and young adults from transitioning from e-cigarettes to traditional cigarettes and minimize the potential public health harm from e-cigarette use, there is a critical need for e-cigarette regulation, legislative action, and counterpromotion to protect youth.

## DEFINITIONS

- **Electronic cigarette (e-cigarette):** handheld devices that produce an aerosol from a solution typically containing nicotine, flavoring chemicals, and other additives for inhalation through a mouthpiece by the user (alternative names include “e-cigs,” “electronic cigars [or “e-cigars”], electronic nicotine delivery systems, electronic hookah [or “e-hookah”], hookah sticks, personal vaporizers, mechanical mods, vape pens, pod systems, and vaping devices);
- **secondhand aerosol:** e-cigarette emissions that are discharged into the surrounding environment with e-cigarette use both directly from the e-cigarette and exhaled from the lungs of the user; and
- **thirdhand aerosol:** e-cigarette emissions that remain on surfaces and in dust after e-cigarette use.

## abstract

<sup>a</sup>Department of Pediatrics, Perelman School of Medicine, University of Pennsylvania and PolicyLab, Center for Pediatric Clinical Effectiveness, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; and <sup>b</sup>Department of Pediatrics, The University of Alabama at Birmingham and Children's of Alabama, Birmingham, Alabama

Drs Jenssen and Walley conceptualized the manuscript, drafted the initial manuscript, reviewed the final manuscript, and note substantial involvement and contribution to the manuscript; the members of the Section on Tobacco Control Executive Committee reviewed the manuscript, provided critical appraisal, and note substantial involvement and contribution to the manuscript; and all authors approved the final manuscript as submitted.

This document is copyrighted and is property of the American Academy of Pediatrics and its Board of Directors. All authors have filed conflict of interest statements with the American Academy of Pediatrics. Any conflicts have been resolved through a process approved by the Board of Directors. The American Academy of Pediatrics has neither solicited nor accepted any commercial involvement in the development of the content of this publication.

Policy statements from the American Academy of Pediatrics benefit from expertise and resources of liaisons and internal (AAP) and external reviewers. However, policy statements from the American Academy of Pediatrics may not reflect the views of the liaisons or the organizations or government agencies that they represent.

The guidance in this statement does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

All policy statements from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.

**DOI:** <https://doi.org/10.1542/peds.2018-3652>

Address correspondence to Brian P. Jenssen, MD, MSHP, FAAP. E-mail: [jenssenb@email.chop.edu](mailto:jenssenb@email.chop.edu)

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

Copyright © 2019 by the American Academy of Pediatrics

**To cite:** Jenssen BP, Walley SC, AAP SECTION ON TOBACCO CONTROL. E-Cigarettes and Similar Devices. *Pediatrics*. 2019;143(2):e20183652

## BACKGROUND

E-cigarettes are handheld devices that produce an aerosol from a solution typically containing nicotine, flavoring chemicals, and other additives for inhalation through a mouthpiece by the user.<sup>1</sup> There is wide variability in e-cigarette terminology, product design, engineering, and solution components (ie, electronic liquid [e-liquid]).<sup>2</sup> For the purposes of this Policy Statement update,<sup>3</sup> the term “e-cigarettes” encompasses the wide variety of devices that are known as vapes, “mods,” tanks, and pod systems, including currently popular brands, such as JUUL.<sup>4</sup> E-cigarettes were introduced to the US market in the mid-2000s, and the design of these products has evolved over time, varying considerably in price, quality, and design.<sup>2,4,5</sup> Early products initially resembled conventional cigarettes, with prefilled cartridges of e-liquid, but quickly developed into tank-style systems, with large refillable cartridges, adding variability in the amount and composition of the e-liquid and potential additives.<sup>1,2</sup> More recent e-cigarette products are more diverse in their design, sometimes resembling common items such as a pen, flashlight, or computer flash drive. In addition to product manufacturers referring to the product as “vaping devices,” they are often known as “mods” because of the ability to modify the devices.<sup>1,2</sup> Although commonly referred to as a vapor, the emission from e-cigarettes is most accurately classified as an aerosol, which is a suspension of fine particles in a gas.<sup>6</sup> Nonusers can be exposed involuntarily to the emissions from the exhaled aerosol.<sup>1</sup>

## EPIDEMIOLOGY OF YOUTH E-CIGARETTE USE

Use of e-cigarettes increased dramatically over the past decade,

making them the most common tobacco product used among youth. Because of the shifting landscape in e-cigarette product design and terminology, combined with different survey definitions, various sources are used to capture data on e-cigarette use. Similar trends have been observed across 3 cross-sectional surveys with data on youth use: the National Youth Tobacco Survey, Monitoring the Future, and the Youth Risk Behavior Surveillance System.<sup>7-9</sup> For the latest data as of 2018, the National Youth Tobacco Survey reported 20.8% of high school students and 4.9% of middle school students currently used e-cigarettes (defined as use of an e-cigarette at least 1 day in the past 30 days)<sup>10</sup>; for 2017, Monitoring the Future reported 17% of 12th graders, 13% of 10th graders, and 7% of eighth graders currently used e-cigarettes<sup>8</sup>; while the Youth Risk Behavior Surveillance System reported 13.2% of high school students currently used e-cigarettes.<sup>9</sup> Current e-cigarette use increased considerably among middle and high school students during 2017-2018 (increasing by 78% from 11.7% to 20.8% among high school students),<sup>10</sup> increasing overall tobacco use and reversing a decline observed in recent years.<sup>7-9</sup> More than 3 million high school students and 570 000 middle school students currently use e-cigarettes.<sup>10</sup> E-cigarette use has been documented as highest among boys, non-Hispanic white youth, and Hispanic youth.<sup>7,11</sup> E-cigarette use is generally greatest among adolescents and young adults and decreases with age in adults. Adult e-cigarette users tend to be previous users of combustible tobacco products, such as traditional cigarettes.<sup>2</sup>

## E-CIGARETTE MARKETING, ADVERTISING, AND SALES

E-cigarettes can be purchased in various retail outlets, including vendors that sell tobacco, vape

shops, mall kiosks, gas stations, convenience stores, grocery stores, and pharmacies as well as through online/Internet vendors. E-cigarette companies market their products to children and adolescents by promoting flavors and using a wide variety of media channels, approaches used by the tobacco industry to successfully market conventional tobacco products to youth.<sup>1</sup> E-cigarette companies, many of which are owned by major tobacco companies, use promotional tactics including television advertisements targeted to stations with clear youth appeal<sup>12</sup>; advertisements at the point of sale at retail stores<sup>13</sup>; product Web sites and social media<sup>14</sup>; targeted advertisements through search engines and Web sites that are focused on music, entertainment, and sports<sup>15</sup>; celebrity endorsements; and sponsorships and free samples at youth-oriented events.<sup>1</sup> Many of these e-cigarette methods of advertising are illegal for conventional cigarettes precisely because such tactics promote youth initiation and progression to traditional tobacco product use.<sup>16,17</sup>

E-cigarette advertising has effectively reached youth and young adults and is associated with current e-cigarette use. In 2016, 78.2% of middle and high school students (20.5 million youth) were exposed to e-cigarette advertisements from at least 1 source.<sup>18</sup> Exposure to these advertisements increases intention to use e-cigarettes among adolescent nonusers.<sup>19</sup> It is associated with current e-cigarette use,<sup>20</sup> with increasing exposure being associated with increased odds of use.<sup>21,22</sup> The increased use of and exposure to e-cigarettes among youth, combined with dramatic increases in advertising,<sup>23</sup> have serious potential to undermine successful efforts to deglamorize, restrict, and decrease the use of tobacco products.

## E-CIGARETTE SOLUTION AND HEALTH EFFECTS

Components of e-cigarette solutions generally include nicotine, flavoring chemicals, and other additives (including those unknown and/or unadvertised to the user).<sup>1</sup> Currently, there are no federal quality standards to ensure the accuracy of e-cigarette constituents as advertised or labeled. Refillable cartridges allow the user to deliver other psychoactive substances, including marijuana.<sup>24</sup> Numerous toxicants and carcinogens have been found in e-cigarette solutions, including aldehydes, tobacco-specific nitrosamines, metals, tobacco alkaloids, and polycyclic aromatic hydrocarbons.<sup>25,26</sup> E-cigarette solution has also been shown to be cytotoxic to human embryonic stem cells.<sup>27</sup>

Nicotine is the major psychoactive component of e-cigarette solution.<sup>1</sup> There are often wide discrepancies between the labeled amount and actual nicotine content within the solution.<sup>2</sup> Reported nicotine concentration in e-cigarette solution ranges widely<sup>28,29</sup> and, depending on how the product is used, can be comparable to or exceed the amount of nicotine in a single conventional cigarette.<sup>30</sup> Nicotine is a highly addictive drug that can have lasting damaging effects on adolescent brain development and has been linked to a variety of adverse health outcomes, especially for the developing fetus.<sup>30,31</sup> Nicotine has neurotoxic effects on the developing brain.<sup>32,33</sup> In early adolescence, executive function and neurocognitive processes in the brain have not fully developed or matured. Adolescents are more likely to engage in experimentation with substances such as cigarettes, and they are also physiologically more vulnerable to addiction.<sup>34</sup> The earlier in childhood an individual uses nicotine-containing products, the stronger the addiction and the more difficult it is to quit.<sup>35</sup> The vast majority of adult

smokers initiated tobacco use by 18 years of age.<sup>31</sup>

E-cigarette solutions are often flavored, with thousands of unique flavors advertised.<sup>36,37</sup> Popular options include fruit, candy, and dessert flavors and are appealing to children and youth.<sup>36,37</sup> Availability of flavors is among the most prominently cited reasons for youth e-cigarette use.<sup>38–40</sup> Studies reveal that candy- or fruit-flavored e-cigarettes are more appealing than tobacco flavors to adolescents and young adults.<sup>41,42</sup> Furthermore, adolescents perceive that e-cigarettes with flavors are less harmful than those with tobacco flavors,<sup>41</sup> creating a potential misperception that e-cigarettes with flavors do not contain nicotine.<sup>8</sup> Many of the flavoring chemicals contain aldehydes, known respiratory irritants, in sufficient concentrations to be of toxicologic concern.<sup>37</sup> Flavorings (other than menthol) have been banned in conventional cigarettes since the Family Smoking Prevention and Tobacco Control Act of 2009 because flavoring encourages youth experimentation and regular use and results in addiction.<sup>16,43,44</sup>

Carrier solvents, such as propylene glycol or vegetable glycerin (glycerol), are used in e-cigarette solutions to produce an aerosol that, when heated, simulates conventional cigarette smoke.<sup>1</sup> Although these carrier solvents are used in other settings, there are insufficient data on the health effects of repeated long-term inhalation and exposure to these solvents.<sup>45</sup>

## HEALTH EFFECTS OF E-CIGARETTE AEROSOL

The aerosol generated by e-cigarettes is inhaled and then exhaled by the user, and some of the generated aerosol may be discharged directly into the surrounding environment and deposited on surface areas. Bystanders are exposed to this

secondhand and thirdhand aerosol in a manner similar to that of secondhand and thirdhand cigarette smoke. Known harmful toxicants and carcinogens have been found in e-cigarette emissions.<sup>1,2</sup> These include polycyclic aromatic hydrocarbons<sup>46</sup> as well as nicotine, volatile organic compounds, and fine and ultrafine particles.<sup>47,48</sup> Metal and silicate particles, some of which are at higher levels than in conventional cigarettes, have been detected in e-cigarette aerosol, resulting from degradation of the metal coil used to heat the solution.<sup>49</sup> There are limited data on the human health effects of e-cigarette emissions. Studies suggest adolescent e-cigarette users are at increased risk of cough, wheeze, and asthma exacerbations.<sup>2</sup>

## POISONINGS AND INJURIES

Unintentional exposure to and poisoning from e-cigarette solutions containing nicotine have increased dramatically in the United States since 2011. Although symptoms of acute nicotine toxicity are generally mild and resolve within 12 hours with no treatment, large exposure can be fatal.<sup>50</sup> One child death caused by ingestion of liquid nicotine has been reported in the United States.<sup>51</sup> The Child Nicotine Poisoning Prevention Act of 2015, which was enacted nationally in January 2016, requires containers of liquid nicotine to be in child-resistant packaging; nonetheless, there continue to be thousands of reports of exposure to e-cigarette liquid nicotine yearly to the National Poison Data System.<sup>52</sup> In addition, the lithium-ion batteries used in e-cigarettes have exploded, leading to burns and fires.<sup>2</sup>

## E-CIGARETTE USE AND PROGRESSION TO TRADITIONAL CIGARETTE USE

Studies of US youth who use e-cigarettes identify remarkably consistent findings: adolescents and young adults who use e-cigarettes,

compared with those who do not, are at higher risk of transitioning to traditional cigarettes.<sup>2,53</sup> This finding is based on substantial evidence from several separate, well-designed, longitudinal studies.<sup>54–61</sup> Adolescents and young adults (14–30 years of age) who have used e-cigarettes are 3.6 times more likely to report using traditional cigarettes at follow-up compared with those who had not, according to a recent meta-analysis.<sup>53</sup> In addition, adolescents who use e-cigarettes appear to have fewer social and behavioral risk factors than conventional cigarette users.<sup>56–58,60</sup> These findings raise significant concern that e-cigarettes have the potential to addict a new generation to nicotine and tobacco, slowing or reversing the decline in adolescent cigarette smoking that has occurred over the past 20 years.

### **ROLE IN SMOKING CESSATION AMONG ESTABLISHED SMOKERS**

Health claims that e-cigarettes are effective smoking cessation aids are not currently supported by scientific evidence. According to the National Academies of Sciences, Engineering, and Medicine, there is limited evidence regarding the ability of e-cigarettes to promote smoking cessation.<sup>2</sup> In particular, with a limited number of small, randomized-controlled trials, there is insufficient evidence on the effectiveness of e-cigarettes as a cessation aid compared with no treatment or Food and Drug Administration (FDA)–approved smoking-cessation treatments.<sup>2</sup> Studies in real-world clinical settings of smokers interested in quitting reveal that e-cigarette users have lower rates of successful quitting compared with those who never used e-cigarettes.<sup>62</sup> Given the current state of the science, smokers interested in quitting should seek and be referred to evidence-based, safe, and effective treatments, including nicotine replacement therapy,

behavioral counseling, and additional pharmacotherapy.<sup>63</sup>

For established smokers, e-cigarettes may reduce health risks for the individual user compared with the risk of continued combustible tobacco use.<sup>2</sup> However, the nuance in this finding must be placed in a larger public health context. Tobacco, when used as intended, causes disease, disability, and death.<sup>31</sup> Operationally, even if e-cigarettes themselves pose less risk to the user than other tobacco products, they still represent a significant public health burden in need of further regulation, particularly if they cause more adolescents and adults to begin harmful combustible tobacco use or prevent fewer people from quitting tobacco use.<sup>2</sup>

### **FEDERAL, STATE, AND LOCAL E-CIGARETTE REGULATION**

The federal government first regulated e-cigarettes in 2016 with the Child Nicotine Poisoning Prevention Act and the FDA Deeming Rule, which extended FDA regulatory authority to all tobacco products, including e-cigarettes.<sup>64</sup> FDA regulations of e-cigarettes now include banning sales to people younger than 18 years, requiring photo identification verification from consumers younger than 27 years, banning free samples and vending machine sales, and including a warning statement on e-cigarette packaging and advertising explaining that nicotine is addictive. Following the FDA Deeming Rule, e-cigarette manufacturers will be required to submit a “premarket review application,” which will enable the FDA to assess the public health impact of these products to determine if they can continue to sell them to consumers.<sup>65</sup> However, in 2017, the FDA delayed implementation of the Deeming Rule, allowing e-cigarettes to remain

on the market without premarket review until 2022.<sup>66</sup>

Although only the federal government can regulate the manufacture of tobacco products, states have the ability to regulate how tobacco products are sold and used. Many states and localities have enacted e-cigarette regulations, including applying excise taxes to the purchase price, incorporating e-cigarettes in smoke-free-air laws, implementing point-of-sale restrictions, and raising the minimum purchasing age to 21 years.<sup>67</sup> The State Tobacco Activities Tracking and Evaluation system of the Centers for Disease Control and Prevention tracks individual state laws related to e-cigarettes.<sup>68</sup>

Significant gaps remain in e-cigarette regulation. As of this publication date, federal laws and regulations do not appropriately restrict the advertising of e-cigarettes to youth. Furthermore, with no restrictions on flavored e-cigarettes in general, child-friendly flavors are still available and marketed to youth. In addition, the delayed implementation of the FDA Deeming Rule allows all e-cigarettes currently on the market to continue to be marketed and sold to consumers without FDA review through 2022. In 2018, the American Academy of Pediatrics (AAP) and 6 other health groups filed a lawsuit against the FDA,<sup>69</sup> noting that the agency’s decision to delay product reviews leaves youth vulnerable to the use of these products and deprives the public of critical health information about e-cigarettes that are already on the market. In 2018, the FDA publicly acknowledged the “epidemic of e-cigarette use among teenagers” and proposed regulatory action<sup>70</sup> in response to data demonstrating rapid acceleration in use.<sup>10</sup> As these usage trends continue, with the rapid rise in popularity among youth of the latest generation of e-cigarettes,<sup>71</sup> the need for federal regulation becomes even

more evident. As of this publication date, the FDA is considering policy actions that could protect youth from e-cigarettes, including newer systems like JUUL.<sup>72</sup>

## ONGOING RESEARCH

As the e-cigarette market grows, there is continued need for research to inform regulatory standards and understand the effects of use and exposure across the life span.<sup>2</sup> Additional research is needed to understand the trajectory of addiction among youth and the progression to combustible tobacco products.<sup>1</sup> Studies are needed to determine if and how e-cigarettes may be effective for smoking cessation; these trials must be carefully designed and adequately powered.<sup>2</sup> Finally, research is needed to evaluate effective countermessaging and public health interventions.

Despite the need for ongoing research, the evidence base is sufficient to support immediate regulatory and public health actions. Lessons learned from tobacco control of combustible cigarettes along with available e-cigarette research can be used to build science-based regulations and interventions, including preventing youth access, banning flavors, incorporating e-cigarettes into smoke-free-air laws, regulating marketing practices, and implementing public education programs.<sup>1</sup> It is critical that pediatric health care providers; local, state, and federal governments; and the public health community act immediately to protect youth from these products.

## RECOMMENDED ACTIONS FOR THE PEDIATRICIAN

- I. Screen for e-cigarette use and exposure and provide prevention counseling in clinical practice.
- II. Provide counseling that homes, cars, and places where children

and adolescents live, learn, play, work, and visit should have comprehensive tobacco-free bans that include e-cigarettes as well as combustible tobacco products.

- III. Do not recommend e-cigarettes as a tobacco-dependence treatment product.

## PUBLIC POLICY RECOMMENDATIONS

- I. Reduce youth access to e-cigarettes.
  - a. The FDA should act immediately to regulate e-cigarettes similar to how traditional cigarettes are regulated to protect public health.
  - b. Ban the sale of e-cigarettes to children and youth younger than 21 years.
  - c. Ban Internet sales of e-cigarettes and e-cigarette solution.
- II. Reduce youth demand for e-cigarettes.
  - a. Ban all characterizing flavors, including menthol, in e-cigarettes.
  - b. Ban all e-cigarette product advertising and promotion in forms that are accessible to children and youth.
  - c. Tax e-cigarettes at comparable rates to those of conventional cigarettes.
- III. Incorporate e-cigarettes into current tobacco-free laws and ordinances where children and adolescents live, learn, play, work, and visit.

For more information, including an e-cigarette fact sheet, please refer to the AAP Julius B. Richmond Center of Excellence e-cigarette Web page (<https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Richmond-Center/Pages/Electronic-Nicotine-Delivery-Systems.aspx>).

For additional AAP clinical and policy recommendations to protect children from the harms of tobacco, see “Clinical Practice Policy to Protect Children From Tobacco, Nicotine, and Tobacco Smoke” (<http://pediatrics.aappublications.org/content/early/2015/10/21/peds.2015-3108>), and “Public Policy to Protect Children From Tobacco, Nicotine, and Tobacco Smoke” (<http://pediatrics.aappublications.org/content/136/5/998>).

## CONCLUSIONS

E-cigarettes are the most common tobacco product used among youth. E-cigarettes are marketed and advertised by promoting flavors and using a wide variety of media channels and approaches previously used with success by the tobacco industry to market conventional tobacco products to youth. E-cigarette advertising has effectively reached youth and young adults and is associated with current e-cigarette use. Numerous toxicants and carcinogens have been found in e-cigarette solutions. Adolescents and young adults who use e-cigarettes are at high risk of transitioning to traditional cigarettes. The increasing use of e-cigarettes among youth threatens 5 decades of public health gains in successfully deglamorizing, restricting, and decreasing the use of tobacco products. To prevent children, adolescents, and young adults from transitioning from e-cigarettes to traditional cigarettes and to minimize the potential public health harm from e-cigarette use, there is a critical need for e-cigarette regulation, legislative action, and counterpromotion to help youth live tobacco-free lives.

## ACKNOWLEDGMENT

The Section on Tobacco Control acknowledges Julie Gorzkowski, Director of the AAP Division of Tobacco Control, for her expertise and important contributions to this article.

## LEAD AUTHORS

Brian P. Jenssen, MD, FAAP  
Susan C. Walley, MD, FAAP

## SECTION ON TOBACCO CONTROL, 2018–2019

Judith A. Groner, MD, FAAP  
Maria Rahmandar, MD, FAAP

Rachel Boykan, MD, FAAP  
Bryan Mih, MD, FAAP  
Jyothi N. Marbin, MD, FAAP  
Alice Little Caldwell, MD, FAAP

## STAFF

Julie Gorzkowski, MSW  
Nana Ama Bullock, MPH  
Colleen Spatz, MSBA

## ABBREVIATIONS

AAP: American Academy of  
Pediatrics  
e-cigarette: electronic cigarette  
e-liquid: electronic liquid  
FDA: Food and Drug Administration

**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.

## REFERENCES

1. US Department of Health and Human Services. *E-Cigarette Use Among Youth and Young Adults. A Report of the Surgeon General*. Atlanta, GA: 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; 2016
2. National Academies of Sciences, Engineering, and Medicine. *Public Health Consequences of E-Cigarettes*. Washington, DC: The National Academies Press; 2018
3. Walley SC, Jenssen BP; Section on Tobacco Control. Electronic nicotine delivery systems. *Pediatrics*. 2015;136(5):1018–1026
4. Barrington-Trimis JL, Leventhal AM. Adolescents' Use of "Pod Mod" E-Cigarettes -- Urgent Concerns. *N Engl J Med*. 2018;379(12):1099–1102
5. Hsu G, Sun JY, Zhu SH. Evolution of electronic cigarette brands from 2013-2014 to 2016-2017: analysis of brand websites. *J Med Internet Res*. 2018;20(3):e80
6. Cheng T. Chemical evaluation of electronic cigarettes. *Tob Control*. 2014;23(suppl 2):ii11–ii17
7. Wang TW, Gentzke A, Sharapova S, Cullen KA, Ambrose BK, Jamal A. Tobacco product use among middle and high school students - United States, 2011-2017. *MMWR Morb Mortal Wkly Rep*. 2018;67(22):629–633
8. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. *Monitoring the Future National Survey Results on Drug Use: 1975-2017: Overview, Key Findings on Adolescent Drug Use*. Ann Arbor, MI: Institute for Social Research, University of Michigan; 2018
9. Kann L, McManus T, Harris WA, et al. Youth risk behavior surveillance - United States, 2017. *MMWR Surveill Summ*. 2018;67(8):1–114
10. 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):1276–1277
11. Arrazola RA, Neff LJ, Kennedy SM, Holder-Hayes E, Jones CD; Centers for Disease Control and Prevention (CDC). Tobacco use among middle and high school students—United States, 2013. *MMWR Morb Mortal Wkly Rep*. 2014;63(45):1021–1026
12. Duke JC, Lee YO, Kim AE, et al. Exposure to electronic cigarette television advertisements among youth and young adults. *Pediatrics*. 2014;134(1). Available at: [www.pediatrics.org/cgi/content/full/134/1/e29](http://www.pediatrics.org/cgi/content/full/134/1/e29)
13. Giovenco DP, Hammond D, Corey GG, Ambrose BK, Delnevo CD. E-cigarette market trends in traditional U.S. retail channels, 2012-2013. *Nicotine Tob Res*. 2015;17(10):1279–1283
14. Huang J, Kornfield R, Szczypka G, Emery SL. A cross-sectional examination of marketing of electronic cigarettes on Twitter. *Tob Control*. 2014;23(suppl 3):iii26–iii30
15. Richardson A, Ganz O, Vallone D. Tobacco on the web: surveillance and characterisation of online tobacco and e-cigarette advertising. *Tob Control*. 2015;24(4):341–347
16. National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General*. Atlanta, GA: Centers for Disease Control and Prevention; 2012
17. US Department of Health and Human Services. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, Office on Smoking and Health; 2012
18. Marynak K, Gentzke A, Wang TW, Neff LJ, King BA. Exposure to electronic cigarette advertising among middle and high school students - United States, 2014-2016. *MMWR Morb Mortal Wkly Rep*. 2018;67(10):294–299
19. Farrelly MC, Duke JC, Crankshaw EC, et al. A randomized trial of the effect of e-cigarette TV advertisements on intentions to use e-cigarettes. *Am J Prev Med*. 2015;49(5):686–693
20. Hammig B, Daniel-Dobbs P, Blunt-Vinti H. Electronic cigarette initiation among minority youth in the United States. *Am J Drug Alcohol Abuse*. 2017;43(3):306–310
21. Singh T, Agaku IT, Arrazola RA, et al. Exposure to advertisements and

- electronic cigarette use among US middle and high school students. *Pediatrics*. 2016;137(5):e20154155
22. Mantey DS, Cooper MR, Glendennen SL, Pasch KE, Perry CL. E-cigarette marketing exposure is associated with e-cigarette use among US youth. *J Adolesc Health*. 2016;58(6):686–690
  23. Cantrell J, Emelle B, Ganz O, Hair EC, Vallone D. Rapid increase in e-cigarette advertising spending as Altria's MarkTen enters the marketplace. *Tob Control*. 2016;25(e1):e16–e18
  24. Grana R, Benowitz N, Glantz SA. E-cigarettes: a scientific review. *Circulation*. 2014;129(19):1972–1986
  25. Goniewicz ML, Knysak J, Gawron M, et al. Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tob Control*. 2014;23(2):133–139
  26. Jensen RP, Luo W, Pankow JF, Strongin RM, Peyton DH. Hidden formaldehyde in e-cigarette aerosols. *N Engl J Med*. 2015;372(4):392–394
  27. Bahl V, Lin S, Xu N, Davis B, Wang YH, Talbot P. Comparison of electronic cigarette refill fluid cytotoxicity using embryonic and adult models. *Reprod Toxicol*. 2012;34(4):529–537
  28. Collaco JM, Drummond MB, McGrath-Morrow SA. Electronic cigarette use and exposure in the pediatric population. *JAMA Pediatr*. 2015;169(2):177–182
  29. Grana RA, Ling PM. "Smoking revolution": a content analysis of electronic cigarette retail websites. *Am J Prev Med*. 2014;46(4):395–403
  30. Soghoian S. Nicotine. In: Hoffman RS, Howland MA, Lewin NA, Nelson LS, Goldfrank LR, eds. *Goldfrank's Toxicologic Emergencies*, 10th ed. New York, NY: McGraw-Hill Education; 2015:1138–1143
  31. US Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta, GA: 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; 2014. Available at: [www.surgeongeneral.gov/library/reports/50-years-of-progress/](http://www.surgeongeneral.gov/library/reports/50-years-of-progress/). Accessed February 11, 2016
  32. Dwyer JB, McQuown SC, Leslie FM. The dynamic effects of nicotine on the developing brain. *Pharmacol Ther*. 2009;122(2):125–139
  33. Schraufnagel DE. Electronic cigarettes: vulnerability of youth. *Pediatr Allergy Immunol Pulmonol*. 2015;28(1):2–6
  34. Pentz MA, Shin H, Riggs N, Unger JB, Collision KL, Chou CP. Parent, peer, and executive function relationships to early adolescent e-cigarette use: a substance use pathway? *Addict Behav*. 2015;42:73–78
  35. Siqueira LM; Committee on Substance Use and Prevention. Nicotine and tobacco as substances of abuse in children and adolescents. *Pediatrics*. 2017;139(1):e20163436
  36. Zhu SH, Sun JY, Bonnevie E, et al. Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tob Control*. 2014;23(suppl 3):iii3–iii9
  37. Tierney PA, Karpinski CD, Brown JE, Luo W, Pankow JF. Flavour chemicals in electronic cigarette fluids. *Tob Control*. 2016;25(e1):e10–e15
  38. Ambrose BK, Day HR, Rostron B, et al. Flavored tobacco product use among US youth aged 12-17 years, 2013-2014. *JAMA*. 2015;314(17):1871–1873
  39. Patrick ME, Miech RA, Carlier C, O'Malley PM, Johnston LD, Schulenberg JE. Self-reported reasons for vaping among 8th, 10th, and 12th graders in the US: nationally-representative results. *Drug Alcohol Depend*. 2016;165:275–278
  40. Tsai J, Walton K, Coleman BN, et al. Reasons for electronic cigarette use among middle and high school students - National Youth Tobacco Survey, United States, 2016. *MMWR Morb Mortal Wkly Rep*. 2018;67(6):196–200
  41. Pepper JK, Ribisl KM, Brewer NT. Adolescents' interest in trying flavoured e-cigarettes. *Tob Control*. 2016;25(suppl 2):ii62–ii66
  42. Harrell MB, Weaver SR, Loukas A, et al. Flavored e-cigarette use: characterizing youth, young adult, and adult users. *Prev Med Rep*. 2016;5:33–40
  43. Deyton L, Sharfstein J, Hamburg M. Tobacco product regulation—a public health approach. *N Engl J Med*. 2010;362(19):1753–1756
  44. Courtemanche CJ, Palmer MK, Pesko MF. Influence of the flavored cigarette ban on adolescent tobacco use. *Am J Prev Med*. 2017;52(5):e139–e146
  45. Callahan-Lyon P. Electronic cigarettes: human health effects. *Tob Control*. 2014;23(suppl 2):ii36–ii40
  46. Schober W, Szendrei K, Matzen W, et al. Use of electronic cigarettes (e-cigarettes) impairs indoor air quality and increases FeNO levels of e-cigarette consumers. *Int J Hyg Environ Health*. 2014;217(6):628–637
  47. Schripp T, Markewitz D, Uhde E, Salthammer T. Does e-cigarette consumption cause passive vaping? *Indoor Air*. 2013;23(1):25–31
  48. Czogala J, Goniewicz ML, Fidelus B, Zielinska-Danch W, Travers MJ, Sobczak A. Secondhand exposure to vapors from electronic cigarettes. *Nicotine Tob Res*. 2014;16(6):655–662
  49. Williams M, Villarreal A, Bozhilov K, Lin S, Talbot P. Metal and silicate particles including nanoparticles are present in electronic cigarette cartomizer fluid and aerosol. *PLoS One*. 2013;8(3):e57987
  50. Mayer B. How much nicotine kills a human? Tracing back the generally accepted lethal dose to dubious self-experiments in the nineteenth century. *Arch Toxicol*. 2014;88(1):5–7
  51. Eggleston W, Nacca N, Stork CM, Marraffa JM. Pediatric death after unintentional exposure to liquid nicotine for an electronic cigarette. *Clin Toxicol (Phila)*. 2016;54(9):890–891
  52. Govindarajan P, Spiller HA, Casavant MJ, Chounthirath T, Smith GA. E-cigarette and liquid nicotine exposures among young children. *Pediatrics*. 2018;141(5):e20173361
  53. Soneji S, Barrington-Trimis JL, Wills TA, et al. Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: a systematic review

- and meta-analysis. *JAMA Pediatr.* 2017;171(8):788–797
54. Primack BA, Soneji S, Stoolmiller M, Fine MJ, Sargent JD. Progression to traditional cigarette smoking after electronic cigarette use among US adolescents and young adults. *JAMA Pediatr.* 2015;169(11):1018–1023
  55. Miech R, Patrick ME, O’Malley PM, Johnston LD. E-cigarette use as a predictor of cigarette smoking: results from a 1-year follow-up of a national sample of 12th grade students. *Tob Control.* 2017;26(e2):e106–e111
  56. Barrington-Trimis JL, Urman R, Berhane K, et al. E-cigarettes and future cigarette use. *Pediatrics.* 2016;138(1):e20160379
  57. Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA.* 2015;314(7):700–707
  58. Wills TA, Knight R, Sargent JD, Gibbons FX, Pagano I, Williams RJ. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii. *Tob Control.* 2017;26(1):34–39
  59. Bold KW, Kong G, Camenga DR, et al. Trajectories of e-cigarette and conventional cigarette use among youth. *Pediatrics.* 2018;141(1):e20171832
  60. Watkins SL, Glantz SA, Chaffee BW. Association of noncigarette tobacco product use with future cigarette smoking among youth in the population assessment of tobacco and health (PATH) study, 2013-2015. *JAMA Pediatr.* 2018;172(2):181–187
  61. Chaffee BW, Watkins SL, Glantz SA. Electronic cigarette use and progression from experimentation to established smoking. *Pediatrics.* 2018;141(4):e20173594
  62. Kalkhoran S, Glantz SA. E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med.* 2016;4(2):116–128
  63. Fiore MC, Jaén CR, Baker TB, et al. *Treating Tobacco Use and Dependence: 2008 Update. Clinical Practice Guideline.* Rockville, MD: US Department of Health and Human Services. Public Health Service; 2008
  64. US Food and Drug Administration. FDA takes significant steps to protect Americans from dangers of tobacco through new regulation. Available at: [www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm499234.htm](http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm499234.htm). Accessed September 9, 2016
  65. US Food and Drug Administration. The facts on the FDA’s new tobacco rule. Available at: <https://www.fda.gov/ForConsumers/ConsumerUpdates/ucm506676.htm>. Accessed April 3, 2018
  66. US Food and Drug Administration. Statement from FDA commissioner Scott Gottlieb, M.D., on pivotal public health step to dramatically reduce smoking rates by lowering nicotine in combustible cigarettes to minimally or non-addictive levels. Available at: <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm601039.htm>. Accessed April 4, 2018
  67. Marynak K, Kenemer B, King BA, Tynan MA, MacNeil A, Reimels E. State laws regarding indoor public use, retail sales, and prices of electronic cigarettes - U.S. states, Guam, Puerto Rico, and U.S. Virgin Islands, September 30, 2017. *MMWR Morb Mortal Wkly Rep.* 2017;66(49):1341–1346
  68. Centers for Disease Control and Prevention. State Tobacco Activities Tracking and Evaluation (STATE) System. 2018. Available at: <https://www.cdc.gov/statesystem/index.html>. Accessed April 4, 2018
  69. McGinley L. FDA sued for delaying e-cigarette, cigar regulations. *Washington Post.* March 27, 2018. Available at: <https://www.washingtonpost.com/news/to-your-health/wp/2018/03/27/fda-sued-for-delaying-e-cigarette-cigar-regulations/>. Accessed April 4, 2018
  70. US Food and Drug Administration. Statement from FDA commissioner Scott Gottlieb, MD, on new steps to address epidemic of youth e-cigarette use. 2018. Available at: <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm620185.htm>. Accessed October 30, 2018
  71. King BA, Gammon DG, Marynak KL, Rogers T. Electronic Cigarette Sales in the United States, 2013-2017. *JAMA.* 2018;320(13):1379–1380
  72. Office of the Commissioner C for TP. Press Announcements - Statement from FDA Commissioner Scott Gottlieb, M.D., on proposed new steps to protect youth by preventing access to flavored tobacco products and banning menthol in cigarettes. 2018. Available at: <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm625884.htm>. Accessed November 28, 2018