E-Cigarettes and Youth: Patterns of Use, Potential Harms, and Recommendations

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ABSTRACT

Electronic cigarette (e-cigarette) use has risen to unprecedented levels among youth in the United States. In this review, we discuss the patterns of use underlying the current youth vaping epidemic, potential harms from e-cigarette use, and the regulatory, public health, and clinical responses to e-cigarette use among youth. Between 2017 and 2018, past 30-day use of nicotine e-cigarettes among high school seniors nearly doubled, from 11% to 21%, representing the largest recorded increase for any adolescent substance use in over four decades. There are concerns that e-cigarette use could renormalize smoking behaviors, lead to the uptake of conventional cigarette use by youth, and have adverse effects in the developing brain and lungs of adolescents. Prevention and harm reduction efforts thus far have focused on policies to prevent youth access to vaping products and on public health strategies to expose the risks of youth vaping. However, it remains unclear if ongoing initiatives are sufficient to curb e-cigarette use by youth. Most health professionals agree that youth exposure to e-cigarettes needs to be addressed but feel uninformed, rely on unconventional information sources such as the media and their patients, and report that routine screening procedures concerning e-cigarettes are lacking. A coordinated effort from policy makers, public health agencies, parents, educators, health practitioners, and researchers is essential to mitigate harms from e-cigarette use in this vulnerable population.

Keywords: Youth, Adolescent, E-Cigarettes, Public Health.

INTRODUCTION

E-cigarettes have rapidly evolved into a multibillion dollar industry since entering the United States market in 2007.[1,2] Their use is referred to as "vaping", due to the heating of a liquid (generally consisting of propylene glycol or glycerin, with or without nicotine) to create a smoke-free aerosol that is inhaled by the user.[3] Of particular concern are the potentially harmful consequences of e-cigarette use among youth, which have been highlighted by many organizations, including the American Academy of Pediatrics and the United States Centers for Disease Control and Prevention (CDC).[4,5] These risks include the downstream initiation of tobacco or other substance use, nicotine dependence and its adverse effects on the developing brain, and impaired lung function due to chemicals and flavorings in e-cigarette liquids.[5,6]

There has been a recent surge in e-cigarette popularity among youth,[7] with new devices regularly entering the market, many of which appeal directly to younger individuals. The accelerating youth vaping epidemic has alarmed officials in government, public health agencies, schools, and the health sector. Prevention and harm reduction efforts are constrained by rapidly evolving patterns of youth e-cigarette use (e.g., preferred device types and flavors, dual use with conventional cigarettes and cannabis), newer generation "pod mod" e-cigarettes (e.g., the increasingly popular JUUL device), and the unknown effects of current e-cigarette policies on youth use. In this review, we synthesize the evidence on patterns and potential harms from youth e-cigarette use and the response from policy makers, public health officers, and health care professionals. We further provide recommendations to reduce possible vaping-related harms among youth and identify areas for future research.

PATTERNS OF YOUTH E-CIGARETTE USE

Trends

As of 2018, 42.2% of American youth in grades 9-12 had ever tried an e-cigarette.[8] This is a dramatic increase from previous years, with an estimated 1.3 million students in grades 9-12 who started vaping nicotine in 2018 in the United States alone.[7] Among 12th grade students, past 30-day nicotine e-cigarette use nearly doubled between 2017 and 2018, from 11% to 21%.[7] This increase was the largest annual increase ever recorded for any adolescent substance use since inception of the Monitoring the Future survey (over four decades ago).[7] These findings parallel those of the 2018 National Youth Tobacco Survey, which found that past 30-day e-cigarette use among high school and middle school students increased 78% and 48%, respectively, from 2017 to 2018.[9] Nicotine vaping has continued to surge among adolescents in 2019; the prevalence of nicotine e-cigarette use in the previous 30 days was 25% among 12th grade students, 20% among 10th grade students, and 9% among 8th grade students.[10]

Many youth who use e-cigarettes also use other tobacco products. Survey data suggest that 77% of middle and high school students who vape also use other tobacco products.[11] However, youth who exclusively use e-cigarettes have lower risk profiles than youth who also smoke conventional cigarettes.[12,13] Compared to dual users, exclusive e-cigarette users are less likely to affiliate with peers who smoke, exhibit lower levels of rebelliousness and sensation seeking behaviors, and demonstrate higher academic involvement.[12] Therefore, the scope of the epidemic suggests that e-cigarettes are enticing youth who would otherwise remain naive to conventional cigarette and nicotine use. In response to the unprecedented rise in adolescent vaping, the United States Surgeon General issued a public advisory urging the nation to take steps to address this epidemic.[14]

Motivations and Flavor Preferences

Curbing the rise in youth vaping requires an understanding of the motivations behind e-

cigarette use in this population. While 55% of adults use e-cigarettes to try to quit smoking conventional cigarettes,[15] fewer than 8% of adolescents use them for this purpose.[16] A 2017 survey of youth and young adults found that commonly cited reasons for initiating e-cigarette use included curiosity, appealing flavors, social bonding, and convenience (e.g., ability to vape discreetly indoors).[17] Motivations for continued e-cigarette use included personal enjoyment and taste,[17] with youth preferring fruit- or dessert-like flavors.[18,19] According to the National Youth Tobacco Survey, youth most often used e-cigarettes due to the influence of a friend or family member who vapes, a belief that e-cigarettes are less harmful than other tobacco products (including cigarettes), and the abundance of available flavors.[16] Flavored e-cigarette use was reported by 61% of youth with past 30-day e-cigarette use and was associated with higher odds of intention to initiate conventional cigarette use among never smokers and reduced perception of risks from tobacco use.[20] Youth may also believe that fruit-flavored e-cigarettes are less damaging to health than tobacco-flavored e-cigarettes.[21] Many youth are also unaware that most e-cigarettes contain nicotine.[22] The development of prevention and cessation strategies that resonate with youth requires an acknowledgement that, whereas adults often turn to e-cigarettes as a smoking cessation or reduction aid, youth may instead be drawn to the novelty and social "relevance" of the product.[23]

Industry and Products

The rapid growth of the vaping sector has generated considerable interest from the tobacco industry. Large tobacco companies now dominate the e-cigarette market, with ownership of (or partial stake in) many of the highest-selling brands.[2] This has formed a reciprocal relationship in which tobacco companies can expand their products and extend their reach (e.g., by selling e-cigarettes in flavors prohibited in conventional cigarettes), while e-cigarette

companies gain capital and visibility by utilizing the resources of well-established corporations. There is substantial proliferation of vaping products, with the market accommodating hundreds of different brands and products.[24]

E-cigarette devices fall under the two main classes of closed system and open system vaporizers. Closed systems cannot easily be modified by the user[25] and typically have a prefilled cartridge and mouthpiece that attaches to a battery.[26] They are disposable or use disposable cartridges and are hallmarked by their small size and simplicity of use. In contrast, open systems can be manually refilled with e-cigarette liquids ("e-liquids") and consist of three defining components: a mouthpiece, a refillable cartridge or tank within a coil system, and a battery.[26] Open systems offer a broader range of experiences to the user and often have many modifiable aspects. For instance, device voltage and wattage can be altered to increase vapor density and the strength of flavor and aerosol production.[26] This flexibility allows users to generate higher nicotine intake per puff from open systems versus closed systems; however, the devices are larger and require greater expertise to operate.[26] Open systems may more easily facilitate other substance use among youth, as refillable chambers also allow users to make additions to commercially-available e-liquids, including with derivatives of cannabis and illicit drugs.[27-29] Data collected prior to 2015 suggest that most youth, particularly frequent users, use open-system e-cigarettes.[25] However, the landscape of vaping products has changed drastically since this time.

Newer generation closed system e-cigarette products called "pod mods" have dramatically altered the vaping market in the United States.[30] Most pod mod devices use a protonated nicotine formulation derived from nicotine salts, unlike most other e-cigarette products, which use free-base nicotine formulations.[30] Protonated nicotine formulations reduce

adverse user experiences (e.g., unpleasant taste, throat irritation), producing a more satisfying experience despite higher nicotine content.[30] These products therefore have the potential to be highly addictive, particularly in smoking-naive populations such as youth, who might otherwise have been discouraged by an unpleasant initial experience with tobacco.[30]

JUUL, a popular pod mod device launched in 2015, currently has over 70% of the retail market share for e-cigarette products,[2] excluding online and specialty store (tobacco and vape shop) sales which are not captured in retail estimates. JUUL has been widely criticized for marketing and social media campaigns targeting youth.[31] The sleek and modern design of the device, which resembles a USB flash drive (Figure 1),[32,33] is easily concealed by youth at school and home and can be personalized using customizable covers known as "skins" (similar to smartphone cases).[30] A JUUL is also very user-friendly; a user simply needs to insert a cartridge or "pod" and draw back on the device to start vaping.[30] In North America, JUUL pods are sold in 1.5%, 3%, or 5% nicotine concentrations and are available in many flavors, including but not limited to cucumber, mango, mint, tobacco, and vanilla.[34] Each 5% pod is equivalent in nicotine content to a pack of 20 cigarettes and could be consumed in as little as a few hours.[35,36] Prior to JUUL, the majority of products were produced in 1-2% concentrations, but a recent study revealed that the high nicotine concentration in JUUL has triggered several competing brands to increase nicotine levels to the range of 5-7%.[35] Of note, in December 2018, Altria Group (the producer of Marlboro cigarettes) purchased a 35% stake in JUUL for $12.8 billion.[37]

POTENTIAL HARMS

Given the host of harmful chemicals released by the combustion of conventional cigarettes, which are absent or present in only trace quantities in e-cigarettes, vaping is likely to be substantially less harmful to health than smoking.[38,39] E-cigarette use could therefore act as a

potential harm reduction option for adult smokers trying to quit. There is evidence to suggest that e-cigarettes may be more effective than traditional nicotine replacement therapies (e.g., patch, gum) for smoking cessation, likely due to e-cigarettes' behavioral similarities to smoking,[40] though further research is still indicated. There are also no data concerning e-cigarettes for smoking cessation in youth, and e-cigarettes are not recommended for uptake by youth or non-smokers due to potential serious risks from vaping.[41] These risks are underscored by recent reports of severe lung injuries (including deaths) in the United States associated with e-cigarette use, primarily among youth and young adults.[41] As of December 2019, more than 2,500 hospitalized cases of e-cigarette associated lung injury have been reported to the CDC from 50 states, the District of Columbia, and two territories, with 55 confirmed deaths.[41] The exact cause of these injuries is as yet unknown; however, the vast majority of cases involved the addition of cannabis derivatives to vaping products.[41,42] Regardless of cause, these injuries highlight the vulnerability of youth and other consumers to unknown vaping-related harms.

The health risks of inhaling e-cigarette vapor are largely unknown. Non-nicotine ingredients in e-cigarettes generally include propylene glycol and/or glycerin, and natural and artificial flavors. Propylene glycol and glycerin are both classified by the United States Food and Drug Administration (FDA) as "generally recognized as safe".[43] Propylene glycol is used as a vehicle in inhaled as well as injected medicines, and in many consumer and household products.[43] Glycerin is a common additive in food and drugs.[43] However, there are concerns that e-cigarette use may increase airway resistance and decrease airway conductance.[44] There is additional evidence which suggests that flavoring chemicals found in e-cigarettes may have adverse effects on lung function by impairing cilia function in the airway epithelium.[6] Adolescents with asthma are particularly vulnerable to adverse lung effects from e-cigarettes,

including increased cough, wheezing, and asthma exacerbations.[45] Risks from inhaling e-cigarette vapor may also exist from second-hand vaping, in which children and youth are exposed to family members or others who vape in close proximity. Concentrations of nicotine, fine and ultrafine particulates, and volatile inorganic compounds increase indoors after vaping.[46-48] In areas with multiple users, airborne particulates and nicotine levels are comparable to levels found in indoor spaces where conventional smoking is permitted (e.g., bars).[49]

Nicotine sickness, colloquially referred to as “nic-sick”, has been increasingly documented by pediatric health care providers amidst the vaping crisis.[50] Unlike conventional cigarette smoking, e-cigarette use does not have a tangible “stop point”. Therefore, youth users lack traditional cues that their vaping session is complete and can inhale continuously from their device for extended periods, inadvertently becoming exposed to higher amounts of nicotine. When nicotine levels exceed tolerable amounts, youth may present with several symptoms of nicotine sickness including abdominal pain, nausea or vomiting, and tremors.[50] More severe cases of nicotine toxicity can lead to breathing difficulties, cardiac arrest, and respiratory failure.[50] Young children in particular are also at risk for poisoning from e-cigarette liquid, which contains highly concentrated nicotine and can lead to nicotine toxicity and death. There were 8,269 reports of liquid nicotine exposures in the National Poison Data System from 2012-2017 in children younger than six years of age (92.5% ingested the liquid).[51] Among these, 1.4% were admitted to a health care facility.

E-cigarette use among youth is of particular concern due to the potential impact of high nicotine levels on the developing brain. During adolescence, the prefrontal cortex (the part of the brain responsible for attention, executive functioning, and impulse control) is undergoing maturation.[29,52] While there are limited human data on the effects of e-cigarette mediated

nicotine exposure on the adolescent brain, conventional smoking among youth has been shown to negatively affect cognitive processing and has been associated with long-term behavioral issues and psychiatric disorders.[52] These findings are supported by well-documented animal data which have shown that nicotine exposure in juveniles leads to noticeable alterations in the cerebral cortex, hippocampus, and midbrain,[53] including changes in cell morphology, changes in gene expression and synaptic transmission, and upregulation of nicotinic acetylcholine receptors.[52] Nicotine may therefore disproportionately impact youth at this stage of development, with cognitive effects that could persist into adulthood.

Other than the direct health risks, there are concerns that e-cigarette use could renormalize smoking behaviors and act as a "gateway" to conventional cigarette or other substance use. The rationale is that e-cigarettes entice youth to engage in smoking-like behavior, often using products with high nicotine content like JUUL.[22,54,55] This raises the potential for youth to become addicted to e-cigarettes, or instead to become "dual users" of e-cigarettes and conventional cigarettes, thereby maintaining or increasing their nicotine intake and behavioral dependence. Several longitudinal studies have reported an association between youth e-cigarette use and downstream conventional cigarette use.[56-60] In a cohort of 6,123 American youth aged 12-15 years, e-cigarette use was associated with four times the odds of subsequent ever conventional cigarette use (odds ratio [OR]=4.09, 95% confidence interval [CI]: 2.97-5.63).[59] Prior users of e-cigarettes were also nearly three times more likely to be regular cigarette smokers at the end of follow-up (OR=2.75, 95% CI: 1.60-4.73).[59] The deleterious health effects of tobacco are well established; it would be extremely detrimental to public health if gateway effects and the renormalization of smoking reversed the decades long decline in tobacco smoking.[61] The expanding legalization of recreational cannabis also raises concerns that e-

cigarette use could act as a catalyst for cannabis uptake among youth.[62] Therefore, youth engaging in these behaviors present a unique public health challenge and require the attention of legislators, public health officials, and health practitioners.

REGULATORY AND PUBLIC HEALTH APPROACHES

Federal Regulations

The growing availability of e-cigarettes has led to substantial changes in federal regulations concerning the manufacture, promotion, and sale of these devices (Figure 2). In the United States, the Deeming Rule, which extended the FDA's regulatory jurisdiction of tobacco products to include e-cigarettes, was finalized in May 2016.[63] This rule included bans on sales to youth under the age of 18, bans on free samples, prohibitions on vending machine sales unless in an adult-only facility, mandatory photo identification for individuals under 27 years of age purchasing e-cigarettes, and health warnings on e-cigarette packaging.[63] Furthermore, the FDA halted new e-cigarette products from entering the market pending premarket approval in accordance with appropriate public health standards.[63] For existing products, applications for premarket approval were given a deadline of August 2018 (later extended to August 2022) with the expectation that most manufacturers could continue to market and sell products while awaiting review.[64] The extension was challenged by many public health advocates and medical groups, and in March 2019, amidst the sharp rise in youth vaping, the FDA proposed to partially revoke its compliance policy.[65] Under the proposed amendments, premarket tobacco applications for flavored e-cigarettes (not including tobacco, mint, and menthol) would need to be received by August 2021.[65] Additionally, manufacturers without premarket approval could be subject to regulatory action – flavored products that increase risk for youth access and any products targeted to or likely to increase use by minors would be prioritized for enforcement.[65]

The FDA also launched its Youth Tobacco Prevention Plan in 2018, directly pursuing legal action against e-cigarette manufacturers and retailers.[66] Between April and September 2018, the FDA issued monetary civil penalties and warnings to nearly 1,400 retailers guilty of selling vaping products to minors.[67] In addition, the agency asked several e-cigarette manufacturers (including JUUL Labs) to provide documents on various aspects of their operation and products. The requested information pertained to consumer complaints, marketing tactics, potential behavioral and physiological effects, product design research, and youth-related adverse events.[66,68] Further action by the FDA in September 2018 targeted five major e-cigarette manufacturers, who were given 60 days to submit plans on reversing the youth vaping epidemic, largely propagated by use of their products by youth.[68] In response to demands from the FDA, JUUL Labs announced in November 2018 that it would remove several fruit and dessert-flavored pods from retail stores, enhance online age-verification procedures, and decrease and refocus its social media presence in an attempt to reduce teen use of their products.[69]

Despite these steps, there is significant room for improvement in limiting potential harms to youth from e-cigarettes.[70] Other potential regulatory avenues have been effective in reducing cigarette smoking in youth and could be applied to e-cigarettes. These strategies include complete bans on product flavoring other than tobacco, bans on advertising, restrictions on use in public places, and taxation of vaping products (youth consumer behaviors being particularly sensitive to pricing). While it is desirable not to enact regulations which might discourage adult smokers from quitting using e-cigarettes, these strategies are likely to have the largest impact on preventing nicotine addiction among youth, with positive long-term consequences for public health. Policy makers should also consider implementing restrictions on the allowable nicotine concentration in e-cigarette liquids and banning the sale of vaping products to youth under the

age of 21. On December 20, 2019, the United States federal government enacted legislation to raise the minimum age of sale for tobacco products (including e-cigarettes) from 18 to 21 years old.[71] However, only 19 states and approximately 530 localities have individually adopted Tobacco 21 legislation, and many of the policies differ substantially with respect to enforcement and penalties.[72] The effectiveness of existing and future regulations is expected to be enhanced by complementary public health approaches.

Public Education Campaigns

In September 2018, the FDA launched "The Real Cost" Youth E-Cigarette Prevention Campaign, an expansion of its 2014 tobacco prevention initiative, to educate children and adolescents about the potential harms associated with vaping.[73] The campaign includes youth-targeted advertisements in schools, on social media, and online, as well as resources for public health stakeholders.[74] Another arm of the FDA's public health effort is "This is Our Watch", an informational campaign to equip retailers with the knowledge and tools required to better understand the federal regulatory framework, as well as strategies to keep e-cigarettes out of the hands of youth.[75] Although the extent to which these initiatives will prevent and reduce youth e-cigarette use remains unclear, "The Real Cost" campaign has previously been effective in combating conventional cigarette smoking among youth. In a nationally representative sample of adolescents, most respondents (88%) were exposed to at least one "The Real Cost" advertisement.[76] The recall of any advertisement was associated with increased perception of the detrimental health effects of cigarette smoking (adjusted OR=5.58, 95% CI: 1.20-25.90).[76] It is estimated that approximately 350,000 youths aged 11-18 years were prevented from initiating smoking between 2014 and 2016 due to "The Real Cost" initiative.[77]

Educational campaigns targeting the parents of children and youth should also be

considered. In a nationally representative survey of middle school and high school parents, 96% of parents had seen or heard of e-cigarettes, but only 44% correctly identified an image of JUUL as a vaping product and only 33% of respondents were concerned about their own child's e-cigarette use.[78] Therefore, there is an opportunity to educate parents concerning youth and vaping. Parents Against Vaping e-cigarettes (PAVe), a parent-led organization, aims to address this gap. PAVe was founded to educate parents on vaping-related harms, encourage parents to support anti-vaping legislation and messaging, and to keep parents informed on the evolving landscape of youth e-cigarette use.[79]

School-Based Interventions

In schools, comprehensive public health measures have been introduced to prevent further escalation of the youth vaping epidemic. Many schools have implemented formal screening programs to identify and assist youth with problematic substance use, presenting a unique opportunity to support students who have already initiated vaping. In the state of Massachusetts, all schools are mandated by law to universally provide Screening, Brief Intervention, and Referral to Treatment (SBIRT), an individual substance use screening protocol, to middle school and high school students.[80] In addition, certain school districts have implemented vaping prevention education programs to raise awareness among students, parents, and teachers. One such campaign, "Vaping Equals", involves anti-vaping posters, online resources, as well as in-class lessons on refusal strategies, vaping-related harms, and youth-targeted marketing in the vaping industry.[81] School administrations have also taken it upon themselves to address the epidemic of youth vaping. In order to enforce bans on e-cigarettes, some schools have removed bathroom doors,[82] installed sensor-alarm systems to detect e-cigarette vapor,[83,84] and even prohibited long sleeves to deter students from hiding their devices

and concealing vaping by blowing vapor into their sleeves.[85] Other schools have issued complete bans on USB devices due to their similarity in appearance to some e-cigarettes.[86]

From prior experiences with tobacco, there is evidence that in-school interventions may be effective in preventing or reducing rates of use among youth. Over one-third of high school students exposed to a school-based anti-tobacco media campaign reported that the posters dissuaded them from smoking and 10% reported that they felt encouraged to quit.[87] A meta-analysis of 50 randomized controlled trials of school-based smoking prevention programs reported a reduction in long-term (greater than one year) smoking initiation in students receiving the intervention versus control (OR=0.88, 95% CI: 0.82-0.95), with a similar, though non-significant, trend at less than one year of follow-up (OR=0.91, 95% CI: 0.82-1.01).[88] Interventions that addressed a combination of social competence (e.g., decision-making, self-esteem) and social influence (e.g., dealing with peer pressure, high-risk situations) appeared to be the most effective, while information-focused, multimodal (involving the community), and social influence-only curricula did not lead to reduced smoking rates.[88] The development of school-based strategies to reduce youth vaping should take lessons learned from smoking programs into account. At present, it remains unclear the extent to which school-based initiatives will impact the epidemic of youth vaping.

CLINICAL PRACTICE

Physician groups have long advocated that younger individuals be aware of the dangers of cigarette smoking and nicotine addiction. Recently, these concerns have been expanded to include e-cigarettes. In 2016, in support of the Surgeon General's report on e-cigarette use among youth and young adults,[29] the American Academy of Pediatrics, the American Academy of Family Physicians, the American College of Physicians, the American Congress of

Obstetricians and Gynecologists, and the American Medical Association called on physicians to counsel pediatric patients on the risks of e-cigarette use and exposure.[89] However, broaching the subject of e-cigarettes with youth remains a complex issue, and physician uptake of this recommendation has been largely inconsistent.

There is a paucity of up-to-date literature on youth-specific e-cigarette practices among health care professionals. In 2014, a nationally representative survey of adults who had ever used an e-cigarette found that fewer than 10% of respondents who visited their physician or their child's physician in the past year reported discussing the benefits or harms of vaping.[90] Physicians were equally as likely to discuss harms as benefits with their patients.[90] In a 2014 national survey of 776 pediatricians and family physicians, 86% routinely screened adolescent patients for cigarette use while only 14% routinely screened for e-cigarette use.[91] Physicians also more routinely counseled against conventional cigarette smoking than vaping (79% vs. 18%).[91] Further evidence from a systematic review found that health care professionals believe that e-cigarettes are more harmful than standard nicotine replacement therapies for smoking cessation and would therefore only recommend e-cigarettes to their patients in specific circumstances, despite patients frequently asking about the devices.[92] These circumstances included heavy smoking, a history of failed quit attempts using standard therapy, patient preference, and the presence of smoking-related comorbidities.[92] However, it seems unlikely that health practitioners would recommend the use of e-cigarettes for smoking cessation to youth; nicotine-containing e-cigarettes were widely perceived as addictive, toxic, and likely to act as precursors to cigarette smoking among younger individuals.[92] Furthermore, whereas e-cigarettes may be an effective smoking cessation therapy in adults,[40] there is no evidence from randomized controlled trials to date on the use of e-cigarettes for smoking cessation in youth.

With the increasing availability of e-cigarettes, there is mounting pressure on health practitioners to engage in front-line prevention and cessation efforts. A 2013 survey of 561 Minnesota health professionals who treat adolescents found that 92% of practitioners were aware of e-cigarettes; however, 83% knew little to nothing about the devices and only 24% had been informed through professional sources.[93] Notably, practitioners have largely relied on the Internet, media channels, and their patients for information on e-cigarettes.[92] The lack of appropriate guidance and formal resources for practitioners, together with competing priorities (i.e., limited time with each patient to address many issues), creates a major barrier to screening for or addressing the issue of e-cigarette use in a clinical setting, as other evidence-based interventions which are more familiar to the health professional may take priority.[92] Moving forward, clear and consistent guidelines from medical organizations and the inclusion of e-cigarette use in tobacco screening procedures will facilitate the role of health care professionals in managing this epidemic. In the meantime, physicians should consider integrating key take-home messages into their clinical practice (Table 1).

RECOMMENDATIONS

Ongoing efforts to mitigate harms associated with youth e-cigarette use should involve a multipronged approach across regulatory, public health, clinical, and research sectors (Table 2). While progress has been made in regulating e-cigarettes to protect youth, additional restrictions on flavors, advertising, nicotine concentration, and age of purchase could further reduce harms and use by youth. Public health approaches, informed by prior research into tobacco prevention, may also be effective; rather than waiting for data specific to e-cigarettes, low-cost interventions should be implemented immediately. In clinical practice, educating health care professionals about e-cigarettes and inquiring about vaping during routine clinical interviews is of low-cost

and may be effective. Contemporary data on the e-cigarette practices of health practitioners are also urgently required. Overall, the research community is needed to clearly establish vaping-related harms among youth and to assess the effectiveness of regulatory, public health, and clinical interventions. Funding agencies will play a crucial role in enabling researchers amidst the growing epidemic; youth e-cigarette use should be considered a priority area for funding.

CONCLUSIONS

Youth vaping has increased dramatically in recent years, beyond that of any previous type of substance use in the past four decades. While e-cigarettes may be less harmful than conventional cigarettes and other substances, there are substantial concerns surrounding a recent outbreak of vaping-related lung injuries in the United States, predominantly among youth and young adults, as well as the potential for e-cigarettes to act as a gateway to conventional cigarette and other substance use. Furthermore, much is still unknown about the health risks associated with e-cigarettes, especially among adolescents, therefore e-cigarette use by this population should be strongly discouraged. Several initiatives have already been implemented to reduce the access and appeal of e-cigarettes to youth, but there is considerable room for improvement. The clinical environment is particularly receptive to targeted e-cigarette guidelines and interventions, with strong consensus from practitioners that youth vaping needs to be addressed. A coordinated effort from policy makers, public health agencies, parents, educators, health practitioners, and researchers is essential to prevent harms from e-cigarette use in this vulnerable population.

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REFERENCES

1. Pauly J, Li Q, Barry MB. Tobacco-free electronic cigarettes and cigars deliver nicotine and generate concern. *Tob Control.* 2007;16(5):357.
2. Herzog B, Kanada P. Nielsen: Tobacco All Channel BiWeekly Data Thru 11/17. 2018. https://athra.org.au/wp-content/uploads/2018/12/Wells-Fargo-Nielsen-Tobacco-All-Channel-BiWeekly-Report-Period-Ending-11.17.18.pdf. Accessed January 17, 2019.
3. Tayyarah R, Long GA. Comparison of select analytes in aerosol from e-cigarettes with smoke from conventional cigarettes and with ambient air. *Regul Toxicol Pharmacol.* 2014;70(3):704-710.
4. American Academy of Pediatrics. Public Policy to Protect Children From Tobacco, Nicotine, and Tobacco Smoke. *Pediatrics.* 2015;136(5):998-1007.
5. Centers for Disease Control and Prevention. Quick Facts on the Risks of E-cigarettes for Kids, Teens, and Young Adults. 2018; https://www.cdc.gov/tobacco/basic_information/e-cigarettes/Quick-Facts-on-the-Risks-of-E-cigarettes-for-Kids-Teens-and-Young-Adults.html. Accessed February 7, 2019.
6. Park H-R, O'Sullivan M, Vallarino J, et al. Transcriptomic response of primary human airway epithelial cells to flavoring chemicals in electronic cigarettes. *Sci Rep.* 2019;9(1):1400.
7. Miech RA, Schulenberg JE, Johnston LD, Bachman JG, O'Malley PM, Patrick ME. *National Adolescent Drug Trends in 2018.* Ann Arbor, MI: Monitoring the Future; 2018.
8. Kann L, McManus T, Harris WA, et al. Youth Risk Behavior Surveillance - United States, 2017. *MMWR Surveill Summ.* 2018;67(8):1-114.
9. 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.
10. Miech R, Johnston L, O'Malley PM, Bachman JG, Patrick ME. Trends in Adolescent Vaping, 2017-2019. *N Engl J Med.* 2019;381(15):1490-1491.
11. Anic GM, Sawdey MD, Jamal A, Trivers KF. Frequency of Use Among Middle and High School Student Tobacco Product Users - United States, 2015-2017. *MMWR Morb Mortal Wkly Rep.* 2018;67(49):1353-1357.
12. Wills TA, Knight R, Williams RJ, Pagano I, Sargent JD. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics.* 2015;135(1):e43-51.
13. Dutra LM, Glantz SA. E-cigarettes and National Adolescent Cigarette Use: 2004-2014. *Pediatrics.* 2017;139(2).
14. Office of the Surgeon General; US Department of Health and Human Services. *Surgeon General's Advisory on E-cigarette Use Among Youth.* Washington, DC: US Department of Health and Human Services; 2018.
15. Zhu SH, Gamst A, Lee M, Cummins S, Yin L, Zoref L. The use and perception of electronic cigarettes and snus among the U.S. population. *PLoS One.* 2013;8(10):e79332.
16. 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.

17. Phoenix Strategic Perspectives Inc. *Qualitative/Quantitative Research on E-cigarette Flavours and Risk Perception.* Ottawa, ON: Health Canada; 2017.
18. Morean ME, Butler ER, Bold KW, et al. Preferring more e-cigarette flavors is associated with e-cigarette use frequency among adolescents but not adults. *PLoS One.* 2018;13(1):e0189015.
19. Shang C, Huang J, Chaloupka FJ, Emery SL. The impact of flavour, device type and warning messages on youth preferences for electronic nicotine delivery systems: evidence from an online discrete choice experiment. *Tob Control.* 2018;27(e2):e152-e159.
20. Dai H, Hao J. Flavored Electronic Cigarette Use and Smoking Among Youth. *Pediatrics.* 2016;138(6).
21. Pepper JK, Ribisl KM, Brewer NT. Adolescents' interest in trying flavoured e-cigarettes. *Tob Control.* 2016;25(Suppl 2):ii62-ii66.
22. Willett JG, Bennett M, Hair EC, et al. Recognition, use and perceptions of JUUL among youth and young adults. *Tob Control.* 2019;28(1):115-116.
23. Romijnders KAGJ, van Osch L, de Vries H, Talhout R. Perceptions and Reasons Regarding E-Cigarette Use among Users and Non-Users: A Narrative Literature Review. *Int J Environ Res Public Health.* 2018;15(6):1190.
24. 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.
25. McMillen R, Tanski S, Wilson K, Klein JD, Winickoff JP. Adolescent Use of Different E-cigarette Products. *Pediatrics.* 2018;142(4):e20180260.
26. Chen C, Zhuang YL, Zhu SH. E-Cigarette Design Preference and Smoking Cessation: A U.S. Population Study. *Am J Prev Med.* 2016;51(3):356-363.
27. Kenne DR, Fischbein RL, Tan AS, Banks M. The Use of Substances Other Than Nicotine in Electronic Cigarettes Among College Students. *Subst Abuse.* 2017;11:1178221817733736.
28. Trivers KF, Phillips E, Gentzke AS, Tynan MA, Neff LJ. Prevalence of Cannabis Use in Electronic Cigarettes Among US Youth. *JAMA Pediatr.* 2018;172(11):1097-1099.
29. 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.
30. Barrington-Trimis JL, Leventhal AM. Adolescents' Use of "Pod Mod" E-Cigarettes - Urgent Concerns. *N Engl J Med.* 2018;379(12):1099-1102.
31. Fadus MC, Smith TT, Squeglia LM. The rise of e-cigarettes, pod mod devices, and JUUL among youth: Factors influencing use, health implications, and downstream effects. *Drug Alcohol Depend.* 2019;201:85-93.
32. Huang J, Duan Z, Kwok J, et al. Vaping versus JUULing: how the extraordinary growth and marketing of JUUL transformed the US retail e-cigarette market. *Tob Control.* 2018.
33. Vapor Vanity. A Juul electronic cigarette, with one 'pod' next to it. *Wikimedia Commons* 2018; https://commons.wikimedia.org/wiki/File:Juul_with_pods_(29395579877).jpg. Accessed May 23, 2019.
34. JUUL Labs Inc. Buy JUUL Pods. 2019; https://www.juul.com/shop/pods. Accessed January 17, 2019.

35. Jackler RK, Ramamurthi D. Nicotine arms race: JUUL and the high-nicotine product market. *Tob Control.* 2019.
36. McKay B. Teen Vaping Has Created Addicts With Few Treatment Options. *The Wall Street Journal.* 2018. https://www.wsj.com/articles/surge-in-teen-vaping-gives-rise-to-nicotine-addiction-11545142195. Accessed February 27, 2019.
37. LaVito A. Tobacco giant Altria takes 35% stake in Juul, valuing e-cigarette company at $38 billion. *CNBC.* 2018. https://www.cnbc.com/2018/12/20/altria-takes-stake-in-juul-a-pivotal-moment-for-the-e-cigarette-maker.html. Accessed May 22, 2019.
38. Cahn Z, Siegel M. Electronic cigarettes as a harm reduction strategy for tobacco control: a step forward or a repeat of past mistakes? *J Public Health Policy.* 2011;32(1):16-31.
39. McNeill A, Brose L, Calder R, Hitchman S, Hajek P, McRobbie H. *E-cigarettes: an evidence update.* London, UK: Public Health England; 2015.
40. Hajek P, Phillips-Waller A, Przulj D, et al. A Randomized Trial of E-Cigarettes versus Nicotine-Replacement Therapy. *N Engl J Med.* 2019;380(7):629-637.
41. Centers for Disease Control and Prevention. Outbreak of Lung Injury Associated with the Use of E-Cigarette, or Vaping, Products. 2020; https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html. Accessed January 3, 2020.
42. Layden JE, Ghinai I, Pray I, et al. Pulmonary Illness Related to E-Cigarette Use in Illinois and Wisconsin - Preliminary Report. *N Engl J Med.* 2019.
43. US Food and Drug Administration. SCOGS (Select Committee on GRAS Substances). 2019; http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=scogslisting&id=262. Accessed May 24, 2019.
44. Palamidas A, Gennimata SA, Kaltsakas G, et al. Acute effect of an e-cigarette with and without nicotine on lung function. *Tob Induc Dis.* 2014;12(Suppl 1):A34-A34.
45. National Academies of Sciences, Engineering, and Medicine. *Public Health Consequences of E-Cigarettes.* Washington, DC: The National Academies Press; 2018.
46. 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.
47. 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.
48. Melstrom P, Koszowski B, Thanner MH, et al. Measuring PM2.5, Ultrafine Particles, Nicotine Air and Wipe Samples Following the Use of Electronic Cigarettes. *Nicotine Tob Res.* 2017;19(9):1055-1061.
49. Chen R, Aherrera A, Isichei C, et al. Assessment of indoor air quality at an electronic cigarette (Vaping) convention. *J Expo Sci Environ Epidemiol.* 2018;28(6):522-529.
50. American Lung Association. What It Means to Be "Nic-Sick". 2019; https://www.lung.org/about-us/blog/2019/10/nic-sick.html. Accessed January 9, 2020.
51. Govindarajan P, Spiller HA, Casavant MJ, Chounthirath T, Smith GA. E-Cigarette and Liquid Nicotine Exposures Among Young Children. *Pediatrics.* 2018;141(5).
52. Goriounova NA, Mansvelder HD. Short- and long-term consequences of nicotine exposure during adolescence for prefrontal cortex neuronal network function. *Cold Spring Harb Perspect Med.* 2012;2(12):a012120-a012120.

53. England LJ, Bunnell RE, Pechacek TF, Tong VT, McAfee TA. Nicotine and the Developing Human: A Neglected Element in the Electronic Cigarette Debate. *Am J Prev Med.* 2015;49(2):286-293.
54. Vallone DM, Bennett M, Xiao H, Pitzer L, Hair EC. Prevalence and correlates of JUUL use among a national sample of youth and young adults. *Tob Control.* 2018.
55. Hammond D, Wackowski OA, Reid JL, O'Connor RJ. Use of Juul E-Cigarettes Among Youth in the United States. *Nicotine Tob Res.* 2018.
56. Barrington-Trimis JL, Kong G, Leventhal AM, et al. E-cigarette Use and Subsequent Smoking Frequency Among Adolescents. *Pediatrics.* 2018;142(6).
57. Unger JB, Soto DW, Leventhal A. E-cigarette use and subsequent cigarette and marijuana use among Hispanic young adults. *Drug Alcohol Depend.* 2016;163:261-264.
58. Spindle TR, Hiler MM, Cooke ME, Eissenberg T, Kendler KS, Dick DM. Electronic cigarette use and uptake of cigarette smoking: A longitudinal examination of U.S. college students. *Addict Behav.* 2017;67:66-72.
59. Berry KM, Fetterman JL, Benjamin EJ, et al. Association of Electronic Cigarette Use With Subsequent Initiation of Tobacco Cigarettes in US Youths. *JAMA Netw Open.* 2019;2(2):e187794-e187794.
60. Hammond D, Reid JL, Cole AG, Leatherdale ST. Electronic cigarette use and smoking initiation among youth: a longitudinal cohort study. *CMAJ.* 2017;189(43):E1328-E1336.
61. Jenssen BP, Walley SC. E-Cigarettes and Similar Devices. *Pediatrics.* 2019;143(2):e20183652.
62. Chadi N, Schroeder R, Jensen JW, Levy S. Association Between Electronic Cigarette Use and Marijuana Use Among Adolescents and Young Adults: A Systematic Review and Meta-analysis. *JAMA Pediatr.* 2019:e192574.
63. US Food and Drug Administration. The Facts on the FDA's New Tobacco Rule. 2016; https://www.fda.gov/consumers/consumer-updates/facts-fdas-new-tobacco-rule. Accessed April 5, 2019.
64. US Food and Drug Administration. FDA announces comprehensive regulatory plan to shift trajectory of tobacco-related disease, death. 2017; https://www.fda.gov/news-events/press-announcements/fda-announces-comprehensive-regulatory-plan-shift-trajectory-tobacco-related-disease-death. Accessed April 5, 2019.
65. US Food and Drug Administration. Statement from FDA Commissioner Scott Gottlieb, M.D., on advancing new policies aimed at preventing youth access to, and appeal of, flavored tobacco products, including e-cigarettes and cigars. 2019; https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-advancing-new-policies-aimed-preventing-youth-access. Accessed April 5, 2019.
66. US Food and Drug Administration. Statement from FDA Commissioner Scott Gottlieb, M.D., on new enforcement actions and a Youth Tobacco Prevention Plan to stop youth use of, and access to, JUUL and other e-cigarettes. 2018; https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-new-enforcement-actions-and-youth-tobacco-prevention. Accessed April 5, 2019.
67. US Food and Drug Administration. Warning Letters and Civil Money Penalties Issued to Retailers for Selling JUUL and Other E-Cigarettes to Minors. 2018; https://www.fda.gov/tobacco-products/ctp-newsroom/warning-letters-and-civil-money-penalties-issued-retailers-selling-juul-and-other-e-cigarettes. Accessed April 5, 2019.

68. US Food and Drug Administration. FDA takes new steps to address epidemic of youth e-cigarette use, including a historic action against more than 1,300 retailers and 5 major manufacturers for their roles perpetuating youth access. 2018; https://www.fda.gov/news-events/press-announcements/fda-takes-new-steps-address-epidemic-youth-e-cigarette-use-including-historic-action-against-more. Accessed April 5, 2019.
69. LaVito A. FDA restricts sales of most flavored e-cigarettes to curb 'astonishing' surge in teen vaping, pursues menthol ban. *CNBC.* 2018. https://www.cnbc.com/2018/11/15/fda-restricts-most-flavored-e-cigarette-sales-pursues-menthol-ban.html. Accessed January 15, 2019.
70. Tulsieram KL, Rinaldi S, Shelley JJ. Recommendations: Will the Tobacco and Vaping Products Act go far enough? *Can J Public Health.* 2017;108(3):e328-e330.
71. US Food and Drug Administration. Selling Tobacco Products in Retail Stores. 2019; https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/selling-tobacco-products-retail-stores. Accessed January 10, 2020.
72. Campaign for Tobacco-Free Kids. States and Localities That Have Raised the Minimum Legal Sale Age for Tobacco Products to 21. 2019; https://www.tobaccofreekids.org/assets/content/what_we_do/state_local_issues/sales_21/states_localities_MLSA_21.pdf. Accessed October 24, 2019.
73. American Association for Respiratory Care. FDA Launches New Campaign on Youth E-Cig Prevention. 2018. https://www.aarc.org/fda-launches-new-campaign-on-youth-e-cig-prevention/. Accessed January 31, 2019.
74. US Food and Drug Administration. FDA In Brief: FDA joins forces with Scholastic to expand distribution of youth e-cigarette prevention posters to every US high school, releases new resources for public health groups as part of Youth Tobacco Prevention Plan. 2018; https://www.fda.gov/news-events/fda-brief/fda-brief-fda-joins-forces-scholastic-expand-distribution-youth-e-cigarette-prevention-posters-every. Accessed May 9, 2019.
75. US Food and Drug Administration. This is Our Watch. 2018; https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/our-watch. Accessed May 9, 2019.
76. Huang LL, Lazard AJ, Pepper JK, Noar SM, Ranney LM, Goldstein AO. Impact of The Real Cost Campaign on Adolescents' Recall, Attitudes, and Risk Perceptions about Tobacco Use: A National Study. *Int J Environ Res Public Health.* 2017;14(1):42.
77. Farrelly MC, Duke JC, Nonnemaker J, et al. Association Between The Real Cost Media Campaign and Smoking Initiation Among Youths - United States, 2014-2016. *MMWR Morb Mortal Wkly Rep.* 2017;66(2):47-50.
78. Patel M, Czaplicki L, Perks SN, et al. Parents' Awareness and Perceptions of JUUL and Other E-Cigarettes. *Am J Prev Med.* 2019;57(5):695-699.
79. Parents Against Vaping E-Cigarettes. Parents Against Vaping E-cigarettes. 2019; https://www.parentsagainstvaping.org/. Accessed November 2, 2019.
80. Massachusetts Screening, Brief Intervention, and Referral to Treatment - Training & Technical Assistance/Boston Medical Center. SBIRT in Schools. 2019; https://www.masbirt.org/schools. Accessed October 25, 2019.
81. Jefferson County Public Schools. Vaping Equals. 2019; https://schools.jefferson.kyschools.us/vapingequals/. Accessed May 19, 2019.

82. Warren P. Vaping Prompts Maryland School To Remove Bathroom Doors. *CBS Baltimore.* 2018. https://baltimore.cbslocal.com/2018/04/23/school-removes-bathroom-doors-vaping/. Accessed January 30, 2019.
83. Teitell B. Schools try different methods to stem students' vaping habits. *The Boston Globe.* 2018. https://www.bostonglobe.com/metro/2018/12/06/everybody-knows-that-vapin-ain-allowed-school/pXHI5Y4Di1ecqTVVyA40vO/story.html. Accessed May 21, 2019.
84. Mielke B, Terez K. NY school installs sensors to cut down on students vaping. *ABC News.* 2018. https://abcnews.go.com/US/ny-school-installs-sensors-cut-students-vaping/story?id=54852303. Accessed May 21, 2019.
85. Deabler A. Texas school changes dress code to battle teen vaping epidemic. *Fox News.* 2019. https://www.foxnews.com/lifestyle/texas-school-changes-dress-code-to-battle-teen-vaping-epidemic. Accessed May 21, 2019.
86. Bui L. Juuling: If you don't know what it is, ask your kids. *The Washington Post.* 2018. https://www.washingtonpost.com/local/public-safety/juuling-if-you-dont-know-what-it-is-ask-your-kids/2018/05/09/37e2f026-4d65-11e8-84a0-458a1aa9ac0a_story.html. Accessed January 30, 2019.
87. Hong T, Johnson CC, Myers L, Boris N, Brewer D, Webber LS. Process evaluation of an in-school anti-tobacco media campaign in Louisiana. *Public Health Rep.* 2008;123(6):781-789.
88. Thomas RE, McLellan J, Perera R. Effectiveness of school-based smoking prevention curricula: systematic review and meta-analysis. *BMJ Open.* 2015;5(3):e006976.
89. Leading Medical Groups Applaud Surgeon General's Report on E-Cigarettes and Youth [press release]. 2016.
90. Drouin O, McMillen RC, Klein JD, Winickoff JP. E-Cigarette Advice to Patients From Physicians and Dentists in the United States. *Am J Health Promot.* 2018;32(5):1228-1233.
91. Pepper JK, Gilkey MB, Brewer NT. Physicians' Counseling of Adolescents Regarding E-Cigarette Use. *J Adolesc Health.* 2015;57(6):580-586.
92. Erku DA, Gartner CE, Morphett K, Steadman KJ. Beliefs and Self-reported Practices of Health Care Professionals Regarding Electronic Nicotine Delivery Systems: A Mixed-Methods Systematic Review and Synthesis. *Nicotine Tob Res.* 2019.
93. Pepper JK, McRee AL, Gilkey MB. Healthcare providers' beliefs and attitudes about electronic cigarettes and preventive counseling for adolescent patients. *J Adolesc Health.* 2014;54(6):678-683.

FIGURE LEGENDS

Figure 1. **The JUUL device.** Adapted from Vapor Vanity (CC BY 2.0 license).[33]

Figure 2. **Milestones of Federal E-Cigarette Regulation in the United States.** Data were obtained from the United States Food and Drug Administration.[63-68] [a]Original deadline was August 2018. The deadline was later extended to August 2022. In March 2019, the deadline was moved forward by a year to August 2021. [b]Original deadline was August 2018.

Table 1. Take-Home Messages for Health Care Professionals and Youth Regarding E-Cigarettes

What should health care professionals know?
– E-cigarettes are very popular among youth. In 2019, 1 in 4 students in the 12th grade, 1 in 5 students in the 10th grade, and 1 in 11 students in the 8th grade vaped nicotine in the past 30 days in the United States. – Youth who would not otherwise smoke conventional cigarettes are being enticed to vape. – Youth who use e-cigarettes are 3-4 times more likely to begin smoking conventional cigarettes, and many youth use both e-cigarettes and other tobacco products. – Many e-cigarettes have concerning levels of nicotine – for example, one 5% JUUL pod contains 20 cigarettes worth of nicotine. Many adolescents are not aware that JUUL contains nicotine and are attracted to its fruity flavors, sleek design, and discreet use. – There are numerous potential harms from vaping among youth, including negative cognitive effects from nicotine exposure, lung damage from flavorings in e-cigarettes, downstream uptake of conventional cigarette use, and e-cigarettes acting as a vehicle for other substance use (e.g., cannabis). – Adolescents with asthma are particularly vulnerable to adverse lung effects from e-cigarettes, including increased cough, wheezing, and asthma exacerbations. – Any youth using an e-cigarette with nicotine for the first time should be viewed as needing immediate intervention. Intervene early to prevent escalation and dependence.
What would we like our children to hear?
– Most e-cigarettes, including flavored e-cigarettes, contain nicotine, and many can have very high nicotine concentrations (e.g., JUUL). – Nicotine is addictive and most dependence starts in adolescence. Once you are addicted to nicotine, it becomes very difficult to stop. – Large tobacco companies control the vaping industry. The goal of these companies is to make money, and they do so by selling addictive products including e-cigarettes and regular cigarettes.

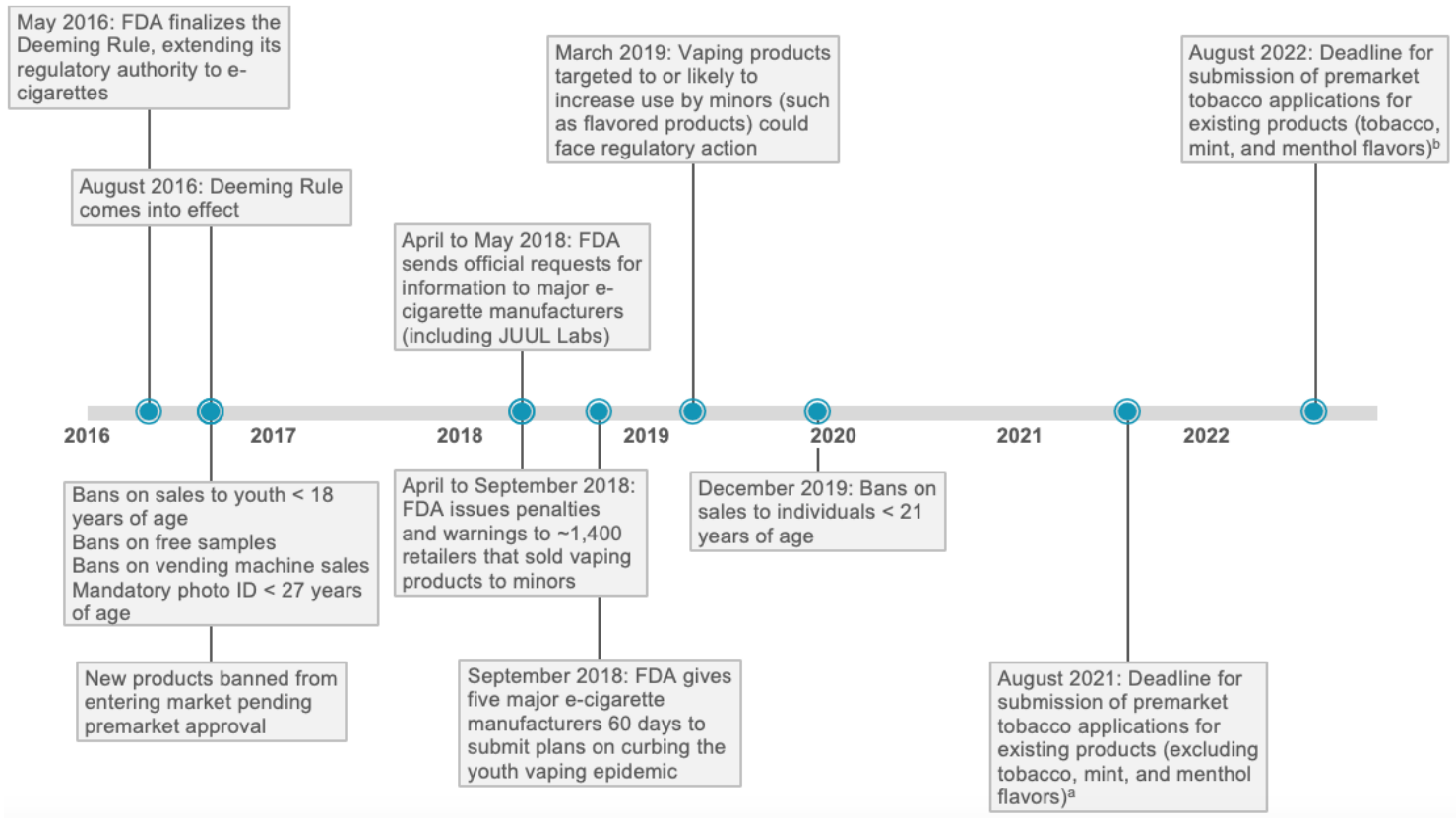
Table 2. Recommendations to Address E-Cigarette Use in Youth

Recommendations
Regulatory
– Flavors, permitted advertising, public use, and taxation should be the same for e-cigarettes as for conventional cigarettes.
– Place a reasonable cap on nicotine concentration in e-cigarette liquids.
– Raise the minimum age to purchase vaping products to 21.
Public Health
– Use what is known about effective public education campaigns and school-based interventions for conventional cigarette smoking to develop equivalent programs for e-cigarette harm reduction.
– Implement low-cost interventions which may be effective while awaiting research on larger prevention programs.
– Educate parents so that they can recognize popular e-cigarette devices, understand common e-cigarette terminology, be informed of the dangers of youth vaping, and know how to discuss vaping with their children.
Clinical
– Educate physicians about the potential harms of e-cigarette use in youth and terms for discussing e-cigarettes (e.g., “vaping”, “JUULing”).
– Inquire about vaping during routine clinical interviews for youth (e.g., “HEADS” – Home, Education, peer group Activities, Drugs, Sexuality).
Research
– Carefully monitor evolving patterns of youth e-cigarette use, particularly in high-priority areas (e.g., JUUL, use of e-cigarettes to vape cannabis).
– Clearly establish vaping-related harms in adolescents, including the short- and long-term effects of nicotine exposure on the developing brain of adolescents, as well as e-cigarette aerosol (via first- or second-hand inhalation) on lung function.
– Explicitly evaluate e-cigarette policy and regulatory initiatives.
– Develop and evaluate (e.g., with well-designed cluster randomized trials) community-, Internet-, and school-based interventions to prevent and curb youth vaping.
– Public funding agencies should prioritize research into preventing harms from e-cigarette use among youth.

Figure 1.


JUUL
STARTER KIT
JUUL Device
USB Charger
4 Flavor Pods
Cool Mint
Virginia Tobacco
Creme Brulee
Mango
5.0% Strength
The Alternative
For Adult Smokers
WARNING:
This product contains nicotine. Nicotine is an addictive chemical.

Figure 2.


May 2016: FDA finalizes the Deeming Rule, extending its regulatory authority to e-cigarettes
August 2016: Deeming Rule comes into effect
March 2019: Vaping products targeted to or likely to increase use by minors (such as flavored products) could face regulatory action
August 2022: Deadline for submission of premarket tobacco applications for existing products (tobacco, mint, and menthol flavors)[b]
April to May 2018: FDA sends official requests for information to major e-cigarette manufacturers (including JUUL Labs)
2016
2017
2018
2019
2020
2021
2022
Bans on sales to youth < 18 years of age
Bans on free samples
Bans on vending machine sales
Mandatory photo ID < 27 years of age
New products banned from entering market pending premarket approval
April to September 2018: FDA issues penalties and warnings to ~1,400 retailers that sold vaping products to minors
September 2018: FDA gives five major e-cigarette manufacturers 60 days to submit plans on curbing the youth vaping epidemic
December 2019: Bans on sales to individuals < 21 years of age
August 2021: Deadline for submission of premarket tobacco applications for existing products (excluding tobacco, mint, and menthol flavors)[a]