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## What is new in electronic-cigarettes research?

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### Abstract

**Purpose of review**—Electronic cigarettes (e-cigarettes) and other vaping devices have seen extraordinary growth in use in the past 10 years, and companies are accelerating their development of new products and marketing efforts. In turn, researchers have increased their efforts to determine how e-cigarettes affect health, how marketing these products impacts adolescents and how the use of e-cigarettes may affect adolescents' use of other tobacco products. Products like Juul were not on the market 2 years ago; thus, frequent updates on the topic are essential.

**Recent findings**—Studies have begun to demonstrate that users of the newer pod systems are exposed to high levels of nicotine, as well as other chemicals. These products are highly marketed, with a strong emphasis on how adolescents can use them surreptitiously. This is concerning to researchers, and other studies have continued to demonstrate that teens who use e-cigarettes are more likely to go on to use combusted tobacco. Further research has also failed to demonstrate that e-cigarettes are useful for people wishing to quit smoking combusted tobacco.

**Summary**—E-cigarettes and vaping systems are not safe products and should not be used by adolescents.

### Keywords

adolescents; electronic cigarettes; vaping

## EMERGING ELECTRONIC CIGARETTE PRODUCTS

Electronic cigarettes (e-cigarettes), in general, use an electric impulse to heat a nicotine containing liquid to the point where it aerosolizes but does not burn. The use of e-cigarettes

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There are no conflicts of interest.

is called ‘Vaping’. It is promoted by the industry as an alternative to smoking; however, studies have not shown that they are effective for smoking cessation. The industry has long used marketing techniques that are appealing to adolescents and young adults, such as cartoons and hyper-sexual imagery. These products are also marketed in a variety of flavors, which are far more appealing to youth than a tobacco-flavored product. The industry has been rapidly innovative, from the cigarette-like products introduced in the early 2000s (Fig. 1) to the ‘mods’ or modified tank systems (Fig. 2) [1]. Recently, the industry has developed e-cigarette products that are more technologically advanced. These products are designed to look like electronic devices, car fobs, coffee cups, credit cards, mobile phones or even tic-tac boxes [2]. Quite distressing to pediatricians are the vaping devices designed to look like asthma inhalers; versions are used to aerosolize marijuana leaf (PUFFiT), or nicotine (QuickNIC). Companies have also developed low vapor and low odor products specifically to facilitate public use.

The JUUL e-cigarette (Fig. 3) was introduced in 2015; by 2016, reports were emerging about its prevalence of use among adolescents. JUUL pods contain 59 mg/ml of nicotine, which is a significantly higher concentration than the standard e-cigarette liquid. A study completed in June 2018 found 148000 videos on YouTube when searching on ‘JUUL’ [2], including 15 000 from ‘JUUL at school’, 1040 from ‘JUUL in school bathroom’ and 6840 from ‘JUUL in class’. A variety of suggested techniques for hiding the aerosol plume includes inhaling more deeply (and increasing nicotine absorption), swallowing the aerosol, exhaling under clothing or into a napkin or paper towel. The study also found YouTube videos detailing how to hide JUUL pods. One video demonstrated the use of a Sharpie marker (Fig. 4) [2].

A recent study evaluated the exposure to nicotine by adolescents who used JUUL and other vape pod systems, using urine samples and teen-reported use of e-cigarettes [3]. In this sample of 506 teens, ages 12–21 years, 7.7% were daily pod users; JUUL was the most popular brand (80%). Bo (36%), Phix (18%) and Suorin (12%) were also popular. The preferred flavors were menthol/mint (24%), fruit (21%) and candy/desserts (18%). The median urinary cotinine of exclusive pod users ( $N=22$ ) in this study was 244.8 ng/ml – an amount higher than has been reported in studies of exclusive combusted tobacco users [4]. Urinary cotinine varied by the type of pod used: the median urinary cotinine of exclusive JUUL users was 135 ng/ml, compared with 508 ng/ml for exclusive Bo users and 906 ng/ml for exclusive Phix users. This study highlights the high levels of nicotine that adolescents are exposed to when they use these vape pod systems.

## ADOLESCENT EXPOSURE TO TOXIC CHEMICALS FROM ELECTRONIC-CIGARETTES

E-cigarettes are promoted as a ‘reduced harm’ product that leads to far less exposure to toxic chemicals than with combusted cigarettes. However, few studies have examined the actual exposures e-cigarette users have. In another study, 67 e-cigarette-only users were evaluated and compared to dual users ( $N=16$ ) and nontobacco using controls ( $N=20$ ). In comparison to the above study, these e-cigarette-only users had a wide range of urinary cotinine levels

(0–864 ng/ml), with a median of 0, suggesting that many users were not exposed to the same degree of nicotine. Further, the study team found that the e-cigarette-only users, compared with controls, had higher levels of the volatile organic compounds (VOCs) acrylonitrile (1.3 vs. 0.8 ng/mg), acrolein (254 vs. 193 ng/mg), propylene oxide (29 vs. 14 ng/mg), acrylamide (67 vs. 42 ng/mg) and crotonaldehyde (149 vs. 130 ng/mg) [5]. Fruit flavor use was also associated with increased levels of acrylonitrile (10 vs. 2 ng/mg). Adolescents who used both tobacco and e-cigarettes had VOC levels up to three times higher than those who used only e-cigarettes. This suggests that even in the absence of high nicotine levels in these products, users are exposed to toxic chemicals – chemicals identified as carcinogenic – created by the vaping of the humectant or flavors. Adolescents should never use e-cigarette or vaping products.

## ELECTRONIC-CIGARETTE USE AMONG YOUTH AND PROGRESSION TO TRADITIONAL CIGARETTE USE

In January 2018, the National Academies of Sciences, Engineering, and Medicine (NASEM, formerly known as the Institute of Medicine), with support from the Center for Tobacco Products of the Food and Drug Administration (FDA), published an expert committee report of the scientific evidence about e-cigarettes and public health. The report, titled the Public Health Consequences of E-Cigarettes, provides both an overview and in-depth analysis of the evidence, recommends ways to improve the research and highlights gaps that are priority focus areas for future work [6].

For youth and young adults, there is substantial evidence that e-cigarette use increases the risk of ever using combustible tobacco cigarettes [6,7]. Further, for e-cigarette users who have also ever used combustible tobacco cigarettes, there is moderate evidence that e-cigarette use increases the frequency and intensity of subsequent combustible tobacco cigarette smoking [6]. These conclusions are based on substantial evidence from several separate, well-designed, longitudinal studies [8–15]. Adolescents and young adults (aged 14–30) who have used e-cigarettes are 3.6 times more likely to report using cigarettes at follow-up, compared to those who had not, according to a recent meta-analysis [7]. In addition, adolescents who use e-cigarettes appear to have fewer social and behavioral risk factors than conventional cigarette users [10–12,14].

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. Data have begun to influence policy, with the FDA recently acknowledging adolescent e-cigarette use as an epidemic. ‘E-cigs have become an almost ubiquitous — and dangerous — trend among teens,’ FDA Commissioner Scott Gottlieb, M.D., said in a statement in September 2018. ‘The disturbing and accelerating trajectory of use we’re seeing in youth, and the resulting path to addiction, must end’ [16].

## ELECTRONIC-CIGARETTES FOR SMOKING CESSATION FOR ESTABLISHED SMOKERS

Health claims that e-cigarettes are effective smoking cessation aids are not currently supported by scientific evidence. According to the NASEM report, there is limited evidence regarding the ability of e-cigarettes to promote smoking cessation [6]. In particular, with a limited number of small, randomized controlled trials, there is insufficient evidence on the effectiveness of e-cigarettes as cessation aids compared with no treatment or to FDA-approved smoking cessation treatments [6]. A more recent large-scale, randomized controlled trial found that the use of free e-cigarettes does not result in higher rates of sustained abstinence than traditional smoking-cessation aids and does not increase abstinence rates among smokers who are also offered information and motivational text messages [17].

The overall evidence from observational trials is mixed [6]. When compared to randomized controlled trials, it is inherently more difficult to draw conclusions about the relationship between cause and effect because of the potential for selection bias and unmeasured confounding. Two systematic reviews that included cohort studies published between 2013 and 2015 in meta-analyses each found a negative association between e-cigarette use and cessation, meaning e-cigarette users have lower rates of successful quitting compared to never e-cigarette users [18,19]. The NASEM report identified that more recent prospective longitudinal studies report that daily or very frequent e-cigarette use may be associated with cessation, whereas intermittent use may not [6]. 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 [20].

For established smokers, e-cigarettes may reduce health risks for the individual user compared to the risk of continued combustible tobacco use [6]. However, tobacco, when used as intended, causes disease, disability and death [21], and discussions and messaging about individual tobacco products must be placed in a larger public health context. 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 [6].

## AREAS FOR FURTHER RESEARCH

The NASEM report closed with a call for action: 'More and better research is needed to help clarify whether e-cigarettes will prove to reduce harm—or induce harm—at the individual and the population levels.' [6] 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 lifespan [6]. Additional research is needed to understand the trajectory of addiction among youth and the progression to combustible tobacco products [22]. Studies are needed to determine whether and, if so, how e-cigarettes may be effective for smoking

cessation [6]. Finally, research is needed to evaluate effective counter-messaging and public health interventions, especially regarding preventing adolescent e-cigarette initiation.

## CONCLUSION

New research in 2018 is strongly pointing to the potential for e-cigarette products to expose their users to toxic chemicals, the likelihood of addicting adolescents to nicotine and possible future combusted tobacco use and the continued failure of rigorous studies to show that these products are effective for smoking cessation. The FDA has delayed the implementation of tighter regulations on e-cigarette products, but this year has recognized the dangers of adolescent exposure and targeted companies such as JUUL for their appeal to teens. Pediatricians and other healthcare practitioners that provide care to young adults and adolescents should continue to stress the dangers of using these products to patients and their parents as well as advocate for restrictions on the purchase and use of these products by teens.

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■ of special interest

■■ of outstanding interest

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**KEY POINTS**

- Recent evidence highlights the high levels of nicotine that adolescents are exposed to when they use vape pod system e-cigarettes, such as JUUL.
- Even in the absence of high nicotine levels in these products, users are exposed to toxic chemicals – chemicals identified as carcinogenic – created by the vaping of the humectant or flavors.
- For youth and young adults, there is substantial evidence that e-cigarette use increases the risk of ever using combustible tobacco cigarettes.
- According to the National Academy of Science report on the public health consequences of e-cigarettes, there is limited evidence regarding the ability of e-cigarettes to promote smoking cessation.
- Pediatricians and other healthcare practitioners that provide care to young adults and adolescents should continue to stress the dangers of using these products to patients and their parents as well as advocate for restrictions on the purchase and use of these products by teens.





**FIGURE 1.**  
First generation e-cigarette.

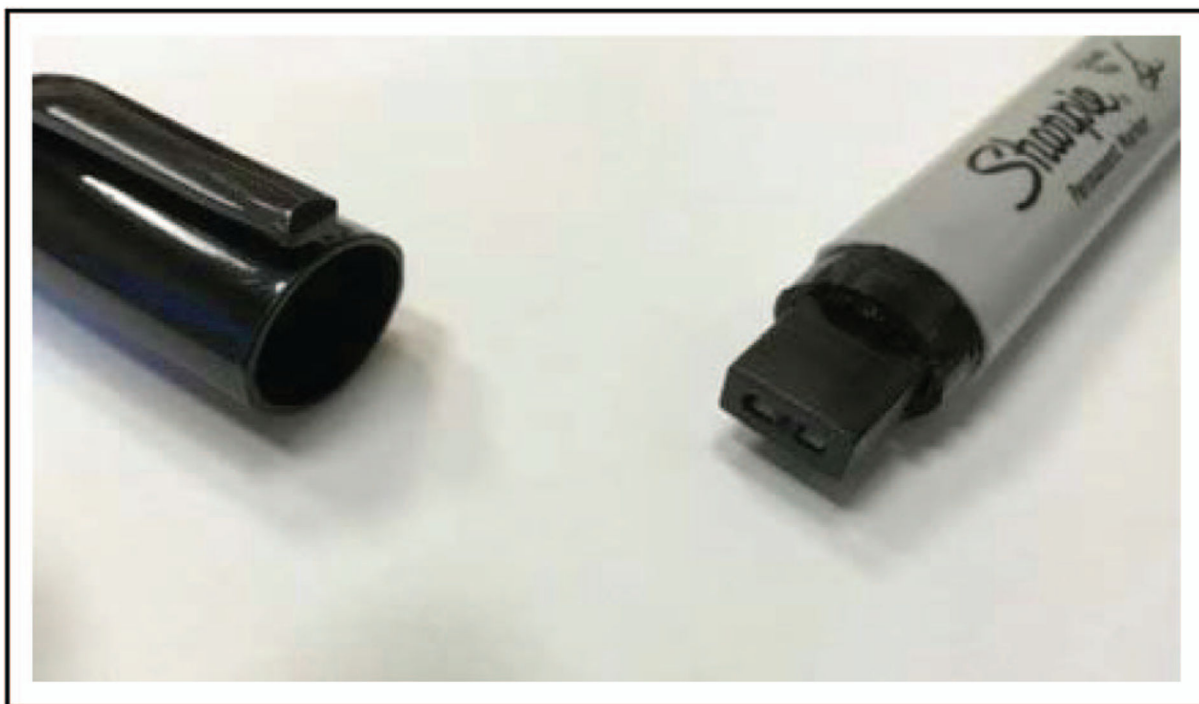




**FIGURE 2.**  
Tank system or 'Mod'.



**FIGURE 3.**  
JUUL with pods. Permission: Susanne Tanski, MD, MPH.



**FIGURE 4.**  
Hiding JUUL in a Sharpie. Source: Ramamurthy *et al.* [2].