



E-Cigarettes: Tobacco Policy and Regulation

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Abstract

Purpose of the Review The purpose of this review is to describe current trends in e-cigarette use, provide an overview of the potential health risks and benefits, and discuss tobacco policy and regulatory considerations.

Recent Findings E-cigarette use is popular among youth and adults, despite limited evidence about the long-term risks or benefits. Internationally, there is wide variability in how e-cigarettes are classified, which has also led to large differences in regulations on these products. Regulatory policies that strike a balance between the potential benefit of these devices for adult smokers who are trying to quit smoking with reducing the appeal and addictive potential for youth are critically needed.

Summary Continued research on the health effects and consequences of e-cigarette use will be essential to inform e-cigarette product standards and tobacco regulatory policies as scientific research strives to keep pace with the ever-changing landscape of e-cigarette technology.

Keywords E-cigarette · Vaping · Electronic cigarette · Tobacco · Regulation · Policy

Introduction

Electronic cigarettes (e-cigarettes) are battery-operated devices that are used to heat and inhale an aerosolized e-liquid solution that contains flavors, other chemical additives, and may contain nicotine. The current e-cigarette market contains many different types of devices (see Table 1). By 2014, there were over 466 different brands of e-cigarettes [1]. Early e-cigarette devices (e.g., “cig-a-likes”) closely resembled a traditional cigarette and were disposable or rechargeable and had a fixed amount of nicotine. Later generation devices such as vape pens, hookah pens, and advanced vaporizers were more customizable, allowing users to change the nicotine concentration, temperature, and voltage, and e-liquid constituents. More recent e-cigarette devices include “pod” devices, such as JUUL, which are often discreet and technologically advanced (e.g., shaped like a USB memory stick). These pod devices are now among the most popular e-cigarette products on the market [2, 3].

While e-cigarettes were initially introduced to the market as a potential cleaner form of nicotine for adult cigarette smokers, evidence on the efficacy of different e-cigarette devices to help smokers quit smoking, as well as on the health effects and long-term consequences of use, is still emerging as scientific research strives to keep pace with the ever-changing landscape of e-cigarette technology. In the meantime, youth use of these products has increased rapidly [4•], and a forecast report from 2017 indicates that the e-cigarette industry is expected to continue growing to over \$26 billion in sales worldwide by 2023 [5]. There is also emerging use of e-cigarette devices to vaporize a variety of other substances like synthetic cannabinoids and methamphetamine [6, 7], raising concerns about exposure to other substances with these devices.

The purpose of this review is to describe current trends in e-cigarette use, provide an overview of what is currently known regarding potential health risks and benefits, and discuss tobacco policy and regulatory considerations.

Prevalence and Appeal



E-cigarette use is prevalent among both youth and adult populations. The appeal of e-cigarettes among youth and adults appears to be related to the presence of many appealing flavors (recently estimated as over 15,000 distinct flavors [8•]), and common perceptions that e-cigarettes are a safer alternative to cigarettes [8•, 9–14].

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Table 1 Examples of e-cigarette device type.

Device Type	Description
 <p data-bbox="440 583 549 611">Cig-a-like</p>	<p data-bbox="743 548 1327 611">First generation, disposable, not refillable, shaped like a cigarette, low delivery of nicotine</p>
 <p data-bbox="440 915 549 942">Vape pen</p>	<p data-bbox="743 915 1273 942">Rechargeable battery and refillable tank for e-liquid</p>
 <p data-bbox="293 1402 699 1434">Mods or advanced personal vaporizers</p>	<p data-bbox="743 1335 1286 1434">Highly customizable, customized battery and tank to modify voltage and temperature, refillable tank for e-liquids</p>
 <p data-bbox="296 1770 695 1797">Pod system (e.g., JUUL, Phix, Suorin)</p>	<p data-bbox="743 1703 1310 1797">Rechargeable, has nicotine salt pods that insert into the device and can deliver high concentrations of nicotine. JUUL device is pictured here, charges with USB port.</p>

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E-cigarettes appear to be particularly appealing to youth and are now the most commonly used tobacco product among youth in the USA [15]. Recent national estimates indicate that in 2018, over 3.6 million middle and high-school students in the US reported using e-cigarettes in the past 30 days, corresponding to 20.8% of high-school students and 4.9% of middle-school students [4]. According to a recently published systematic review [16] of youth surveys from 13 countries (US, Korea, New Zealand, UK including Scotland and Wales, Poland, Canada, Hungary, China including Hong Kong, France, Ireland, Italy, Iceland and Greece) between 2013 and 2015, the prevalence of e-cigarette use among youth ≤ 20 years was highest in Poland (62.1%) and lowest in Italy (5.9%). The review also observed that these rates appear to vary based on smoking status; specifically, among non-smoking youth, e-cigarette use rates varied from 4.2% in the US to 14.0% in New Zealand, and among tobacco smoking youth, the rates varied from 29.9% in Italy to 71.9% in Canada.

Furthermore, there is evidence that surveys assessing e-cigarette prevalence rates may actually underestimate the rate of use among youth [17], since some devices that are popular with youth are commonly known by unique terminology (e.g., “juuling” for the popular JUUL pod system [3]), and users of these devices may not endorse “e-cigarette use” because they do not consider these products to be e-cigarettes. Survey data indicate that youth seem to prefer more advanced generation e-cigarettes and use multiple types of devices [18, 19].

Further, results from the 2015 National Youth Tobacco Survey in the US indicate that among youth who had never tried e-cigarettes before, 32.1% of middle-school and 38.4% of high-school youth were susceptible to future use, reporting that they might experiment with e-cigarettes in the future or use an e-cigarette if offered by a friend [20••]. Longitudinal evidence indicates that susceptibility to future e-cigarette use is a significant predictor of e-cigarette initiation as soon as 6 months later [21]. Ongoing research is examining factors that influence susceptibility among youth [22–24], and these results are important for developing effective prevention campaigns. For example, results from a nationally representative sample of US youth indicated that perceptions of e-cigarettes as addictive and harmful are associated with decreased susceptibility to use [23]. However, about 80% of youth do not perceive great risk of harm from regular use of e-cigarettes [25].

Among adults, global estimates of current e-cigarette use vary across different countries, ranging from $< 5\%$ (e.g., Canada, UK) to 14% (e.g., Malaysia), reported in the International Tobacco Control Surveys from 2009 to 2013 [26]. Additionally, the prevalence of e-cigarette use among adults has increased over time across several countries [27–29]. Business reports from 2018 estimates of

global sales indicate that the US is currently the largest market for e-cigarette products [30, 31]. National US estimates from 2017 indicated that while traditional combustible cigarettes remained the most commonly used tobacco product (14.0%, 34.3 million adults), 6.9 million adults (2.8%) reported e-cigarette use in the past 30 days [32].

E-Cigarette Safety and Health Effects

E-cigarette use remains prevalent even though the safety and health effects of both acute and long-term use of e-cigarettes are still being determined. While e-cigarettes contain significantly fewer chemicals than those found in cigarettes, the aerosol generated from vaporizing e-liquids still contains many chemicals [33]. As detailed in a recent National Academies of Sciences report on e-cigarettes [34••], the following substances were identified in e-liquids and e-liquid aerosols: nicotine, propylene glycol, glycerin, tobacco-specific nitrosamines, aldehydes, volatile organic compounds, phenolic compounds, polycyclic aromatic hydrocarbons, a variety of flavoring chemicals (for example, acrolein and furfural), and tobacco alkaloids. While the levels of many of these compounds were lower than in combusted tobacco products, many of these agents are known respiratory toxins, inflammatory agents, and carcinogens, and it is unknown if the negative health effects are mitigated at lower exposure levels. However, a recent review suggests that e-cigarette use could be associated with pulmonary toxicity and increased incidence of asthma [35].

While the flavor chemicals in e-liquids and the solvents like propylene glycol and glycerin are generally recognized as safe for edible consumption, there is limited information on their safety following long-term exposure through inhalation. Recent evidence suggests that flavor chemicals can have toxic effects [36–39], and that e-liquid components can degrade into known toxicants when heated and vaporized [40–42]. Propylene glycol and glycerin have been identified as the source of many carbonyl compounds which have known toxicities [43, 44]. Many e-liquids may also contain alcohol as solvents, at levels high enough to influence psychomotor performance [45]. The aerosols can also contain metallic particles like chromium, cadmium, and lead, generated from the heating coils in the e-cigarette devices [46]. The levels of all these chemicals and their metabolites, as well as the metals, can be increased when e-liquids are vaporized at higher temperatures. Many e-cigarette devices allow users to modify the power and temperature in order to produce a better “throat hit” [47]. Thus, potential for high exposure to these chemicals exists, especially when e-cigarette devices are used for recreational behaviors that are popular among

youth, like cloud chasing or vape tricks [48, 49] and “dripping” [50, 51], which involve vaporizing e-liquids at high temperatures to create thick vapor.

E-cigarettes can also expose users to high levels of nicotine. E-liquids are available in a wide variety of nicotine concentrations, with levels ranging from 0 ng/ml (i.e., no nicotine) to over 85 mg/ml [52], and a single e-liquid cartridge for some devices can contain the same amount of nicotine that is in a full pack of cigarettes [3]. Reports indicate many youth who use e-cigarettes do not know if they have used nicotine or not [53], which raises concerns about the potential for inadvertent exposure to nicotine. While most devices use a free-base nicotine solution, many of the newer pod devices contain a nicotine salt. Free-base nicotine is rapidly absorbed and produces rapid peaks in blood nicotine concentrations that can mimic combustible cigarettes, but it is also harsh and causes irritation [54]. In contrast, nicotine salt e-liquids contain free-base nicotine in combination with benzoic acid which lowers the pH of the e-liquid and allows for smoother delivery of higher doses of nicotine without throat irritation [54, 55]. While the higher levels of nicotine delivered in these nicotine salt solutions with pod devices (such as JUUL) may be beneficial to smokers who are trying to quit smoking combustible cigarettes, there is a lack of empirical evidence on this issue. It is also concerning that these pod-devices like JUUL are very popular among youth [3], and it was recently observed that youth who used JUUL had higher urine cotinine levels than a sample of youth who regularly smoked combustible cigarettes [56], indicating greater exposure to nicotine from these e-cigarettes and the potential for developing nicotine addiction.

It is important to remember that nicotine is not only addictive but influences many organ systems in the human body through its activity at the nicotinic acetylcholine receptor system. Acute effects of nicotine include a rapid increase in pulse rate and blood pressure, as well as an increase in the levels of catecholamines in the blood [57, 58]. Nicotine also leads to increases in plasma-free fatty acids, hyperglycemia, an increased rate of respiration, endothelial dysfunction, and inflammation, and increases in blood viscosity [34, 59–61]. Chronic exposure to nicotine can change the functioning of all these systems. For example, nicotine use via e-cigarettes influences many cardiovascular markers [60–62], and there is evidence that e-cigarette use is associated with increased risk of myocardial infarction [63]. Importantly, nicotine is also a well-established neurotoxin in the adolescent brain [64]. The adolescent brain is highly susceptible to the effects of nicotine [65], and nicotine exposure during adolescence can interfere with development and cognitive functioning [66, 67] and lead to nicotine addiction [66, 68].

Development of Nicotine Addiction and Progression to Other Substance Use Among Youth

In addition to potential toxicant exposure from e-cigarette constituents, e-cigarette use raises other concerns especially for youth. Data suggest that e-cigarettes are often the first tobacco product tried by youth [69, 70], and youth who are exposed to nicotine through these devices are at risk for nicotine addiction [71, 72] and progression to other substance use, including combustible tobacco products [73, 74]. Nicotine is highly addictive, and nicotine dependence can develop quickly in adolescents [75]. Longitudinal studies indicate that even minimal exposure to nicotine only a few times puts youth at greater risk for later addiction [68].

Emerging evidence indicates youth e-cigarette users experience many symptoms of dependence, including craving or a strong urge to use e-cigarettes [71, 72]. Studies of high-school aged students indicate youth who first tried e-cigarettes at a younger age were at greater risk for e-cigarette dependence [72], and higher dependence is associated with lower odds of wanting to quit e-cigarettes [71]. Thus, there is evidence that some youth are progressing beyond initial experimentation with e-cigarettes and developing dependence. Recent reports indicate some youth are using e-cigarettes frequently; in 2018, over a quarter of US high-school students who used e-cigarettes reported using the product on more than 20 out of the past 30 days [4].

E-cigarette use may also put youth at risk for other tobacco use. Youth who use e-cigarettes report greater intentions to smoke cigarettes [76, 77], and there is evidence from longitudinal studies that youth who use e-cigarettes are significantly more likely to transition to conventional cigarette use over time [73, 78–81]. E-cigarette use predicts subsequent cigarette use even among youth who use e-cigarettes infrequently; one study showed that youth were significantly more likely to initiate conventional cigarette smoking whether they previously used e-cigarettes only 1–2 times (odds ratio OR = 2.88, 95% CI = 1.96–4.22) or as often as weekly/daily (OR = 4.09, 95% CI = 2.43–6.88) [82].

In addition to increasing the risk for future cigarette smoking, e-cigarette use may also put youth at risk for other substance use. Longitudinal studies indicate e-cigarette users are at higher risk for initiating and using marijuana over time [74], and national survey studies in the US report that 10% of youth used e-cigarette devices to vape marijuana in 2017 [25]. Thus, e-cigarette use among youth poses risk for nicotine dependence and other substance use.

Effects on Smoking Cessation and Dual Use Among Smokers

On the one hand, e-cigarettes may be beneficial for public health if they serve as a smoking cessation aid, providing an

alternative way to obtain nicotine with fewer harmful chemicals than combustible cigarettes. Some population survey studies support this notion, indicating greater rates of quit attempts or cessation success among adult cigarette smokers who use e-cigarettes [83–86], while other studies report lower rates of smoking cessation among e-cigarette users [87–90]. Systematic reviews conclude that there is currently very low-quality evidence supporting e-cigarettes for smoking cessation [91•, 92], in part because there is a need for more well-designed randomized controlled trials and longitudinal studies. Synthesizing equivocal results across studies is difficult because there is wide variability across studies in e-cigarette device characteristics (e.g., device type, nicotine level, flavor), use behavior (e.g., frequency and duration), and subject-related factors (e.g., quitting motivation, nicotine dependence) that may impact cessation outcomes. Preliminary evidence also suggests that the variability in the real-world effectiveness of e-cigarettes for smoking cessation may be related to the regulatory environment for these products, and that smokers in countries that have stricter regulations (e.g., Canada, Australia) are less likely to use these devices in unassisted quit attempts [93•].

Very few randomized controlled trials have been published that evaluate the efficacy of e-cigarettes for smoking cessation. In one trial, participants who were *not intending to quit* smoking in the next 30 days were randomized to one of two nicotine e-cigarettes or a placebo (no-nicotine) e-cigarette [94]. All participants significantly reduced their cigarette consumption throughout the study, and there were no statistically significant differences in median cigarettes per day or biochemically confirmed quit rates at 6-month and 1-year follow-ups among the three groups. A separate study that recruited smokers who were *motivated to quit* randomized participants to use a nicotine e-cigarette, placebo e-cigarette, or nicotine patch, and everyone received minimal behavioral support to quit smoking through telephone counseling [95]. Although those in the nicotine e-cigarette group reduced their cigarette consumption more than those in the nicotine patch group, the nicotine e-cigarette was not superior to the placebo e-cigarette, and there were no significant differences in biochemically confirmed continuous abstinence rates at 6 months between the three groups. A meta-analysis pooled the results of these two studies and concluded that there is some evidence that nicotine containing e-cigarettes are more effective than placebo (no-nicotine) e-cigarettes for reducing or stopping smoking [91•]. However, the combined effect size estimate was very small (5%) and the authors of the meta-analysis graded the evidence as low quality given the small number of studies analyzed. Additional studies are needed to understand the potential role of e-cigarettes for smoking cessation, especially as e-cigarette devices continue to evolve. Importantly, these two earlier studies evaluated the efficacy of first-generation e-cigarettes that have now been replaced

by newer devices that are more efficient at delivering nicotine and therefore may be a more effective substitute for combustible cigarettes.

Other randomized trials have compared e-cigarettes to standard tobacco treatment. One study was a pragmatic trial offering smoking cessation interventions to employees who smoked regardless of their current interest in quitting [96]. Everyone received usual care (e.g., information on the benefits of quitting and access to a free text messaging service, SmokeFreeTXT from the National Cancer Institute), and some were randomized to one of several additional interventions. The primary outcome was biochemically confirmed sustained smoking abstinence 6 months later. Quit rates were low for all groups, and results indicated there were no differences between those randomized to receive free e-cigarettes, free cessation aids (e.g., nicotine replacement therapy or pharmacotherapy), or usual care alone.

A separate study recruited patients who were attending stop-smoking services in the UK and randomized them to receive either 3 months of nicotine replacement therapy (NRT) of their choice, including combinations of NRT products or an e-cigarette starter pack [97•]. Contrary to prior trials, all participants in this study also received weekly face-to-face behavioral support for at least 4 weeks. Results indicated significantly higher 1-year biochemically confirmed sustained abstinence rates among the e-cigarette group (18.0%) compared to the NRT group (9.9%). These data suggest e-cigarettes are effective for promoting abstinence from combustible cigarettes when combined with face-to-face behavioral support to quit smoking. However, of those who achieved abstinence at 1 year, 80% in the e-cigarette group were still using the device and remain exposed to nicotine and other chemicals from e-cigarette use, while only 9% were still using NRT.

These recent results show promise for the role of e-cigarettes in smoking cessation, although many questions still need to be answered in order to inform smokers about how to use these products to help them quit. For example, research is needed to identify what is the adequate dosage and duration of e-cigarette use to promote cessation, as well as how to combine e-cigarettes with other cessation aids or counseling, and how and when to discontinue e-cigarette use after quitting. A search of a trial registry (clinicaltrials.gov) shows there are multiple ongoing studies across various countries evaluating the use of e-cigarettes for smoking cessation, and we hope additional data will inform the use of these devices to optimize smoking cessation and reduce harm.

In general, e-cigarettes may be an effective harm reduction strategy if they substitute completely for smoked cigarettes. However, dual use of both cigarettes and e-cigarettes is common [26, 32], and longitudinal results from the US Population Assessment of Tobacco and Health study (PATH 2013–2015) indicate that over 44% of adult dual users of e-cigarettes and

cigarettes maintained their dual use over time [98]. While dual use may be reducing harm exposure if e-cigarettes are replacing combustible cigarette use, there is the potential that e-cigarette use actually increases nicotine exposure if these devices are used in places where combustible smoking is not allowed (e.g., indoors), rather than as a substitution. Additionally, dual users continue to be exposed to the harmful effects of conventional cigarettes. Data on the health effects of cigarette smoking indicate that even light smoking (i.e., 1–4 cigarettes per day) significantly increases risk for cardiovascular problems and cancer [99, 100]. Furthermore, there is evidence that cigarette and e-cigarette use independently contribute to cardiovascular [63] and pulmonary risk [101], such that dual users of both products are at even greater risk compared to those using only cigarettes or e-cigarettes alone. Ultimately, there may be limited public health benefit if e-cigarette use reduces cigarette consumption but does not promote total abstinence from cigarettes; data on the long-term health effects are needed to address this question.

Additionally, among youth and young adults, evidence indicates that e-cigarette use is not associated with smoking cessation or reduction. Results from surveys and observational cessation studies of youth and young adults indicate e-cigarette use is associated with lower motivation to quit smoking cigarettes [102] and a lower likelihood of stopping smoking [103]. Additionally, results from one study indicate that adolescents who are dual users of both e-cigarettes and cigarettes actually smoke more cigarettes, not fewer [104]. Dual use is especially concerning among youth because it increases the risk for developing nicotine dependence [105].

Ultimately, smokers need to be educated about the potential benefits and harms of e-cigarettes, and in the absence of strong evidence supporting e-cigarettes for cessation and guidance about how to use these devices to promote quitting, they should be encouraged to first consider other evidence-based methods to quit smoking, including available pharmacotherapies and behavioral counseling [106].

Regulatory Policy

The potential public health impact of e-cigarettes is complex. Regulatory policies that strike a balance between the potential benefit of these devices for adult smokers who are trying to quit smoking with reducing the appeal and addictive potential for youth are critically needed. But, establishing these regulatory policies is complex and challenging, and current regulations have not been able to keep up with the rapid market growth in e-cigarette devices and e-liquids.

Internationally, there is wide variability in how e-cigarettes are classified, which has also led to large differences in regulations of these products [107]. According to evidence presented on a Global Tobacco Control website hosted by Johns Hopkins University [108], which was extracted from the

World Health Organization (WHO) report on electronic nicotine delivery systems [109], of 98 countries examined, 70 classify e-cigarettes as vaping products, 57 as tobacco products, 24 as medicinal products, 18 as consumer products or devices, and 4 regulate these as poisons or hazardous substances because they contain nicotine with no medicinal purpose. The report further observed that the use of policies that has been standardly applied to combustible tobacco products like minimum age of purchase, restrictions on sales/marketing/packaging, product regulation, as well as inclusion in clean air and taxation laws, also vary widely around the world. Only 36 countries have minimal age of purchase/sales for these devices. With regard to sales, a large majority either ban sales of all types of e-cigarettes (29 countries) or regulate sales or require marketing authorization prior to sales (45 countries). The WHO report also indicates that 67 countries prohibit or regulate e-cigarette marketing, and 38 require health warnings on e-cigarette packaging. With regard to the product itself, 32 countries regulate the amount of nicotine in e-liquids, 32 do not permit the use of harmful ingredients other than nicotine, and 31 regulate the quality of e-liquid content. Finally, 49 countries prohibit or restrict use of e-cigarettes in public places, and only 13 countries tax e-cigarettes. The WHO report strongly encouraged countries that had not already banned e-cigarettes to consider applying some of the above regulatory policies, along with strong monitoring. Strong monitoring of these policies is critical for understanding the impact on public health. For example, although regulations in Australia prohibit the sale, possession, or use of nicotine-containing e-cigarettes, results from the 2013 International Tobacco Control Survey indicated 43% of current e-cigarette users surveyed in Australia reported using an e-cigarette with nicotine [29]. Changes in tobacco regulations and enforcement of these policies have the potential to greatly influence e-cigarette use. We provide below an example of how e-cigarette regulation has changed over time in the US.

Regulations in the US In the US, e-cigarettes are regulated as tobacco products under the Family Smoking and Prevention Tobacco Control Act (FSPTCA) which passed in 2009 [110]. The original FSPTCA only covered cigarettes, cigarette tobacco, roll-your-own tobacco, and smokeless tobacco, and required that any tobacco product that appeared on the market after February 15, 2007, would need to get approval from the US Food and Drug Administration (FDA). The FSPTCA gave FDA the authority to enforce federal controls on sales of tobacco products to children; require that tobacco companies post ingredient lists for their products; require smokeless tobacco product–warning labels; preserve state, local, and tribal authority; and require that prior to making any claims of reduced harm (also known as modified risk) or no change in harm (also known as substantial equivalence) on any product, an application for that product would need to be submitted to

the FDA and be approved. This law makes it clear that the FDA could not require prescriptions to purchase tobacco products, require the reduction of nicotine yields to zero in any product, or ban face-to-face sales of certain classes of tobacco products in retail outlets. The FDA's regulation of tobacco products must be based on scientific evidence, and the evaluation of any new product is required to consider the risks and benefits of the product to the population as a whole, including users and non-users.

In 2016, the FDA extended its authority to cover “all products that meet the statutory definition of ‘tobacco products,’” including electronic nicotine delivery systems (ENDS: e-cigarettes, e-hookah, e-cigars, vape pens, advanced refillable personal vaporizers, and electronic pipes), and other products such as dissolvables, gels, waterpipe tobacco, cigars, and pipe tobacco [111]. The FDA also required nicotine exposure warnings and child-resistant packaging on all products, including e-liquids. The FDA later announced that in order to ensure they had the appropriate scientific evidence to balance regulation while encouraging development of innovative tobacco products that may be less dangerous than cigarettes, they would delay the deadline for applications for cigars, pipe tobacco, and hookah tobacco to August 8, 2021, and for non-combustible products such as e-cigarettes to August 8, 2022. Manufacturers can continue to market products that have been on the market prior to August 2017 until the product applications are reviewed.

More recently, in November 2018, the FDA released an announcement [112] in response to the significant increase in youth use of e-cigarettes [4], detailing planned regulatory policies that would restrict access to flavored e-liquids in common retail locations, like convenience stores and gas stations, and require stricter regulations on sales of these devices and e-liquids to minors over the internet. It is worth noting that the majority of sales of these devices come from non-traditional outlets like vape shops and online retailers [113], and many youth report obtaining their devices from online sales [114]. The FDA has also recently launched targeted youth prevention efforts; specifically, they have developed a national e-cigarette prevention campaign aiming to change youth attitudes and beliefs about e-cigarettes [115].

It is expected that these and future regulatory policies will make strides towards decreasing access of e-cigarette devices to youth while maintaining access to individuals trying to quit smoking, but the path is not an easy one. For example, there is a significant concern that although limiting access to a variety of e-liquid flavors may reduce the appeal of e-cigarettes to youth, this regulation may also lead to decreases in smoking cessation efforts for adult smokers who are using these devices to quit smoking. Importantly, because e-cigarettes are regulated as a tobacco product in the US, rather than another product category, there are limits to the kinds of regulatory

policies that can be implemented. For example, the FDA cannot require a prescription for e-cigarettes to encourage use only by adult smokers wanting to quit. Additional research on e-cigarette product characteristics, marketing, and access will be needed to inform US regulatory policies to reduce the appeal to youth and limit the potential toxicity for users.

Conclusions

E-cigarettes hold a lot of potential for use as part of a harm reduction strategy for smoking cessation in cigarette smokers. However, the current evidence to support the use of e-cigarettes to quit smoking is limited. Additional clinical research is needed to determine the optimal frequency and duration of use as well as the specific devices, constituents, and e-liquid features that may aid in smoking cessation. Utilization of these devices for smoking cessation should be accompanied by a strong behavioral counseling program and would likely involve a taper to wean subjects off nicotine to avoid the potential for returning to combustible product use.

Future efforts also need to focus on implementing regulatory policies as well as developing prevention and education programs to reduce e-cigarette use in youth to avoid new initiation of nicotine use and addiction, while supporting quitting efforts for current smokers. E-cigarette regulatory policies vary widely by country, and the range of classifications of e-cigarettes (e.g., tobacco product vs. medicinal product) influences the type of regulations that can be made. As the e-cigarette industry continues to evolve, the development of evidence-based regulatory policies and ongoing monitoring will be critical for establishing product standards and ensuring that e-cigarettes are available as part of a harm reduction approach to help smokers quit while restricting youth use and preventing renormalization of nicotine addiction.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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- Of major importance

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