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## Youth and Young Adult Use of Pod-Based Electronic Cigarettes From 2015 to 2019: A Systematic Review

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### Abstract

**IMPORTANCE**—The use of electronic cigarettes (e-cigarettes) has rapidly increased among youth and young adults, but knowledge gaps exist on the potential health effects of using recently introduced pod-based e-cigarettes.

**OBJECTIVE**—To conduct a systematic review of recent peer-reviewed scientific literature on pod-based e-cigarettes.

**EVIDENCE REVIEW**—A search of online databases, including PubMed, Web of Science, Embase, and EBSCO HOST, was conducted to identify pod-based e-cigarette-associated articles

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from June 2015 (the time when JUUL [JUUL Labs] was introduced) to June 2019. We included English-language articles that presented primary data on pod-based e-cigarettes.

**FINDINGS**—Pod-based e-cigarettes represent a substantial evolution in design by increasing the efficient delivery of nicotine. While these products may contain less harmful constituents than other types of e-cigarettes and cigarettes, there is no evidence that the levels found are safe among youth. There is evidence for higher nicotine dependence associated with their use. Pod-based e-cigarette brands, compared with other e-cigarette brands, have targeted youth and young adults with social media marketing. There was less discussion about the use of these products as smoking cessation devices or their health risks on social media. The social acceptability and favorable perceptions of pod-based e-cigarettes may underlie the use of these products.

**CONCLUSIONS AND RELEVANCE**—The appeal and dependence potential of pod-based e-cigarettes for youth emphasize the need for stronger regulations on product design, social media, marketing channels, and youth access together with health communications that emphasize the risks of nicotine dependence.

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Pod-based electronic cigarettes (e-cigarettes) are a new form of e-cigarettes named from their replaceable podstyle nicotine cartridges. Pod-based e-cigarettes have become popular among youth in part because of efficient nicotine delivery,<sup>1</sup> appealing flavors,<sup>2,3</sup> sleek designs, and ease of concealment.<sup>4</sup> Since its market entry in 2015, JUUL (JUUL Labs) has dominated e-cigarette retail sales,<sup>5</sup> although other products are now in the market, including Suorin (Suorin USA), Bo (Bo Vaping), Phix, and Vuse Alto (RJR Vapor Co).<sup>6</sup> Recent data have shown that e-cigarette use in adolescents has increased substantially since the introduction of pod-based e-cigarettes,<sup>7,8</sup> prompting the US Surgeon General to declare youth vaping an epidemic.<sup>9</sup>

Despite public concerns about the proliferation of pod-based e-cigarettes, there are substantial knowledge gaps about the design and function of these products and the health risks they pose. Although a body of research on pod-based e-cigarettes has emerged, to our knowledge the findings have not yet been synthesized to provide a deeper understanding of the factors that have prompted this epidemic and its consequences for population health. A comprehensive review of research to date should also identify gaps in knowledge needed to be addressed to inform regulatory policies and interventions. Because multiple systematic reviews on earlier generations of e-cigarettes have been conducted,<sup>10–15</sup> in this article we only review new research on pod-based e-cigarettes specifically.

## Methods

We systematically searched for peer-reviewed research on pod-based e-cigarettes published between June 2015 to March 15, 2019. We used a string of keywords (eFigure in the Supplement) to obtain articles from PubMed, Embase, Web of Science, and EBSCO Host. In addition, given the fast-paced nature of articles in this domain, we repeated a search on PubMed and Web of Science using the same keywords for recently published articles up to June 30, 2019.

We combined and deduplicated articles from databases using the Covidence software.<sup>16</sup> Two coders (S.L. and N.Y.) assessed the relevance and eligibility of each article based on the abstract and full text. The eligibility criteria for inclusion were English-language articles and primary research on pod-based e-cigarettes. We excluded articles that did not present primary data (eg, commentaries and editorials), those not focused on youth or young adults, and articles that did not distinguish between pod-based e-cigarettes and other e-cigarettes. The eFigure in the Supplement summarizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of our literature search. Because of the heterogeneity of studies, we inductively classified articles into categories based on content area. Four authors (S.L., N.Y., V.R., and A.T.) reviewed articles within each category and extracted data of each study's funding, research questions and data source, methods, key findings, conclusions, and rated study quality and noted limitations (eTable in the Supplement). We then highlighted key results across studies for each category.

## Results

Thirty-five articles were included in the final review. Seven articles (20.0%)<sup>1,6,17–21</sup> focused on JUUL and other brands of pod-based e-cigarettes while all the others focused on JUUL specifically. One article was funded by JUUL Labs.<sup>22</sup> While this article did not differ substantially from other studies in terms of methods and results, research funded from industry sources may be subject to inherent conflicts and should be viewed with caution.<sup>23</sup> Eighteen studies (51.4%) were youth or young adult focused<sup>1,2,6,17–20,22,24–33</sup> while 2 studies (5.7%) also included older adult populations.<sup>3,34</sup> Because of the nature of early evidence, most studies with human participants used cross-sectional surveys (vs clinical trials) focusing on trends in use, attitudes, and knowledge (eTable in the Supplement). Articles were categorized by their content area into (1) product design and biological effects (9 [25.7%])<sup>1,18,24,35–40</sup>; (2) marketing (4 [11.4%])<sup>5,41–43</sup>; (3) social media communication (7 [20.0%])<sup>21,32,33,44–47</sup>; and (4) population use and perceptions (15 [42.9%]).<sup>2,3,6,17,19,20,22,25–31,34</sup> Studies that included data from more than 1 category (marketing + social media communication,<sup>5</sup> product design and biological effects + population use and perceptions<sup>24</sup>) were summarized by the findings relevant to each category. A summary of findings and relevant policy and research recommendations for each category can be found in the Table and key themes are highlighted later in this article.

### Product Design and Biological Effects

Key themes that emerged in this category included nicotine delivery and exposure, dependence potential compared with other e-cigarettes, and toxicants compared with other e-cigarettes. Studies in this category analyzed nicotine and toxicants of pod-based e-cigarette fluids and aerosols (5 [14.3%]),<sup>35–39</sup> in vitro cytotoxicity (1 [2.9%]),<sup>40</sup> product use patterns, and resulting human exposure levels to nicotine (3 [8.6%]).<sup>1,18,24</sup>

**Nicotine Delivery and Exposure**—JUUL e-cigarettes have a very low fraction of free nicotine in the pod liquid and aerosol compared with other types of e-cigarettes (about 5%–6% free nicotine compared with 13%–95%, respectively) but a high total nicotine content in the form of benzoate salt.<sup>35,37–40</sup> This formulation ensures the delivery of high doses of

nicotine in a low pH form, which is less harsh compared with the higher pH nicotine found in most other e-cigarette brands, thus supporting deeper inhalation by consumers. The level of nicotine exposure in 38 adolescents (as measured by urinary cotinine) using pod-based e-cigarettes was higher (245 µg/L [to convert to nanomoles per liter, multiply by 5.675]) than levels detected in adolescent regular cigarette smokers (155 µg/mL).<sup>1</sup>

**Dependence Potential Compared With Other e-Cigarettes**—Adolescents using pod-based e-cigarettes were more likely than other e-cigarette users to vape daily and show greater nicotine dependence symptoms.<sup>18</sup> For example, a survey of 517 e-cigarette users age 12 to 21 years found that more pod-based e-cigarette users were categorized as daily users compared with other e-cigarette users, with 76% of pod-based e-cigarette users reporting use in the past day (vs 30% among other e-cigarette users).<sup>18</sup> A longitudinal observational study conducted among e-cigarette users age 13 to 18 years (N = 173) found that the proportion of e-cigarette users reporting JUUL as their most common device increased from 22% at baseline to 48% over a 12-month period.<sup>24</sup>

**Toxicants Compared With Other e-Cigarettes and Cigarettes**—An analysis of aerosol emissions found that, compared with other forms of e-cigarettes and cigarettes, JUUL had lower levels of certain harmful constituents, such as benzene,<sup>36</sup> volatile organic compounds, free radicals, carbonyls, formaldehyde, and total aldehydes.<sup>37,39</sup> However, 1 study found that JUUL e-liquids had a cytotoxic association with human lung epithelial cells examined in vitro.<sup>40</sup>

## Marketing

Key themes that emerged in this category included JUUL sales and social media marketing, nicotine content and stealth features, and sales despite US Food and Drug Administration (FDA) interventions. Studies in this category included an analysis of JUUL retail sales and marketing expenditures (1 [2.9%]),<sup>5</sup> online searches of pod-based e-cigarette brands on Google and YouTube (2 [5.7%]),<sup>41,42</sup> and online searches of JUUL and pod sales on eBay (1 [2.9%]).<sup>43</sup>

**JUUL Sales and Social Media Marketing**—JUUL annual sales exceeded \$650 million in 2017. JUUL spent a relatively modest amount on marketing between 2015 and 2017 (\$2.1 million) across television, print, radio, and internet compared with other e-cigarette brands, such as Vuse, which spent more than \$16 million on television in 2015 and 2016 alone.<sup>5</sup> Instead JUUL used an innovative and highly efficient strategy that prioritized marketing using social media, including Twitter, Instagram, and YouTube, and via affiliate marketers, such as Instagram accounts of online e-cigarette retailers and product reviews on YouTube by users.<sup>5</sup>

**Other e-Cigarette Brands Increasing Nicotine Content and Introducing Stealth Features**—With JUUL's success in the market, partly fueled by its high nicotine content, other e-cigarette vendors have increased the nicotine content in e-liquid and JUUL-compatible pods and begun to offer the popular mango flavor and imitation devices (small, elongated, and pod-based). Moreover, other e-cigarette vendors have developed and

advertised products that are discrete and have low odor and low vapor levels; common stealth vaporizers resemble pens, asthma inhalers, mobile phones, and other small electronic devices that can easily be concealed from adults.<sup>42</sup>

**JUUL Online Sales Despite FDA Intervention**—In April 2018, the FDA requested that eBay remove online sales listings for JUUL. While evidence showed that eBay listings posted before FDA's request were no longer active, 50% of those vendors continued to post other live listings for JUUL products or sold them without mentioning the brand name.<sup>43</sup>

### Social Media Communication

Key themes that emerged in this category included positive and negative sentiments, popularity on social media among youth, discussion of experiences of using JUUL and lifestyle appeals on social media, and the lack of communication about health risks. Studies in this category conducted analyses of JUUL-associated tweets on Twitter (4 [11.4%]),<sup>32,44,46,47</sup> characteristics of users who follow JUUL's Twitter account (2 [5.7%]),<sup>32,33</sup> JUUL-associated Reddit posts (2 [5.7%]),<sup>45,46</sup> JUUL-associated Instagram posts and YouTube videos (1 [2.9%]),<sup>5</sup> and Instagram posts of KandyPen, another brand of pod-based e-cigarettes (1 [2.9%]).<sup>21</sup>

**Positive and Negative Sentiments**—A content analysis on Twitter of approximately 1000 tweets revealed mostly positive sentiments (eg, expressing positive emotions toward JUUL use) among young users about JUUL.<sup>47</sup> An analysis of 364 Reddit posts showed mixed sentiments, with adult and youth users expressing negative and positive perceptions of youth JUUL use.<sup>45</sup>

**Popularity on Social Media and Among Youth**—The volume of JUUL-associated Twitter tweets increased 17-fold in 2017 compared with 2016 and there were 35 JUUL-associated YouTube videos that exceeded 100 000 views, suggesting the growing popularity of JUUL over time.<sup>5</sup> An analysis of 9077 users following JUUL's Twitter account estimated that 81% of followers were age 13 to 20 years.<sup>33</sup> Another analysis on Twitter accounts that follow JUUL (N = 721) found that adolescents advocate for JUUL use on social media and retweet JUUL company tweets.<sup>32</sup> These retweeted company tweets reached youth that did not follow JUUL's Twitter account and were separated from them by up to 4 degrees.<sup>32</sup>

**Discussions of Experiences of Using JUUL and Lifestyle Appeals on Social Media**—The main topics discussed regarding JUUL on social media (Twitter and Reddit) include experiences of using or buying JUUL in college or school contexts, reasons for using JUUL (eg, popularity, getting a buzz), barriers to using JUUL (eg, age restriction, price), and JUUL flavors.<sup>44–47</sup> Most posts from the official JUUL Instagram account represented lifestyle appeal (evoking feelings of relaxation, freedom, and sex appeal), product images, customer feedback/testimonies, and flavor images. Posts that featured product images and lifestyle appeals garnered the most endorsements in the form of likes.<sup>5</sup>

**Lack of Communication About Health Risks**—Social media communications rarely addressed the use of JUUL as a cessation strategy, ranging from 0.29% to 16.2% across

studies of posts on Twitter and Reddit.<sup>44,45,47</sup> Only 3.8% of analyzed Reddit posts (N = 364) mentioned health risks.<sup>45</sup> In addition, there was low representation (0.9% of approximately 1000 tweets) from government, education, or antitobacco agencies via the Twitter platform on topics associated with JUUL.<sup>47</sup>

## Population Use and Perceptions

Key themes that emerged in this category included ever use and frequent use prevalence, demographic characteristics of JUUL users, other tobacco use among JUUL users, common reasons for use, and lack of awareness of nicotine in JUUL. Studies in this category comprised qualitative interviews with young adults (1 [2.9%])<sup>19</sup>; cross-sectional nationally representative surveys of youth and young adults (2 [5.7%])<sup>22,30</sup>; cross-sectional nonprobability sample surveys of youth, young adults, and adults from panels, such as Qualtrics (5 [14.3%])<sup>6,27,28,31,34</sup>; a cross-sectional survey of adults from representative and nonrepresentative samples (1 [2.9%])<sup>3</sup>; a longitudinal nonprobability sample survey of adolescents<sup>24</sup> (1 [2.9%]); and surveys of high school (eg, in Connecticut and California) or college students (5 [14.3%]).<sup>2,17,20,26,29</sup>

**Ever Use and Frequent Use Prevalence**—Within 3 years of JUUL’s introduction in the market (2015), based on 2 nationally representative surveys in 2018, youth (15–17 years) prevalence of ever use was 7.6% to 9.5%, past 30-day use was 4% to 6.1%, and frequent use (20–30 days in the past 30 days) was 0.3%.<sup>22,30</sup> Among young adults age 18 to 21 years, ever use was 11.2%, past 30-day use was 7.7%, and frequent use (10–30 days in the past 30 days) was 2.2%.<sup>30</sup>

**Demographic Characteristics of JUUL Users**—JUUL users tended to be white<sup>30</sup> and of higher socioeconomic status or income strata than nonusers.<sup>27,30,31</sup> Other characteristics of JUUL users included having family members who used vapes or used vapes/cigarettes dually and perceiving e-cigarettes to be less harmful than cigarettes.<sup>30</sup>

**Other Tobacco Product Use Among JUUL Users**—In addition, JUUL users tended to use other e-cigarette devices or smoke cigarettes.<sup>2,17,29,30</sup> For example, in a nationally representative sample of youth and young adults (15–34 years), ever and current JUUL users reported more current combustible tobacco use than nonusers.<sup>30</sup> In the same vein, the most common use pattern was using pod-based e-cigarettes, other e-cigarettes, and cigarettes (25%) among 163 ninth-to twelfth-grade California students who used pod-based e-cigarettes.<sup>17</sup>

**Common Reasons for Use**—Social acceptability and convenient product features (eg, high nicotine levels, sleek design) are top reasons for using JUUL among youth and young adults.<sup>2,3,17,19</sup> For example, in a study using qualitative interviews, young adult pod-based e-cigarette users cited other people’s more favorable approval and user-friendly design as reasons they used the product.<sup>19</sup> Similarly, 81% of a convenience sample of college students who ever used JUUL cited “my friends use it” as a reason for initiation while 91% of JUUL current users reported ease of use as the reason they currently used JUUL.<sup>2</sup>

**Lack of Awareness of Nicotine in JUUL**—While JUUL contains nicotine in its currently sold form, there was limited awareness of nicotine content in JUUL. For example, in 2017, only 37% of 30-day JUUL youth and young adult users reported that JUUL always contains nicotine.<sup>31</sup> In a sample of college students, 67.3% reported that JUUL always contains nicotine.<sup>26</sup> Similarly, limited knowledge that JUUL is a nicotine delivery device was found among high school students who had ever used JUUL.<sup>29</sup>

## Discussion

A review of peer-reviewed articles published up to June 2019 on pod-based e-cigarettes revealed a nascent evidence base. Pod-based e-cigarettes represent a substantial evolution in product design that enhances nicotine delivery<sup>35,37–40</sup> and therefore increases the risk of nicotine dependence in adolescent users.<sup>18,24</sup> While research indicates that pod-based e-cigarettes may have lower toxicants than other types of e-cigarettes and cigarettes, to our knowledge there is no literature on the long-term effects of even low levels of toxicant exposure among young users. Therefore, preventing pod-based e-cigarette use among young people must be a priority. Early exposure to nicotine may lead to neurological changes that result in greater severity of dependence symptoms and more substance use.<sup>10</sup> Nicotine dependence may also increase vulnerability to other forms of tobacco marketing as well as peer or social influences that promote the use of other tobacco products.<sup>48</sup> Compounding concerns is evidence that cessation interventions for nicotine dependence have limited success; approximately half of those who become dependent on combusted cigarettes do not achieve long-term abstinence.<sup>49</sup> Thus, the potential for a life span trajectory of nicotine dependence among adolescents is a pressing public health concern.

This early evidence underscores the need for interventions to prevent a further rise in e-cigarette use among young people driven by pod-based products. The US Family Smoking Prevention and Tobacco Control Act of 2009<sup>50</sup> provides the FDA with many regulatory options that can be applied to pod-based e-cigarettes. First, advertising and marketing must be regulated to prevent exposure to youth.<sup>51</sup> Evidence in this review suggests that social media is being used to market pod-based e-cigarettes with high efficiency and substantial reach.<sup>5,21,32,33</sup> Social media marketing campaigns<sup>5</sup> have likely increased favorable perceptions among youth and young adults, which is evident from the rare discussion of health risks and use of these products as a smoking cessation device (JUUL Lab's stated goal).<sup>32,33,52</sup> To prevent the targeting of youth through social media, tobacco manufacturers should be required to impose rigorous restrictions on youth access to their social media accounts. Evidence of the use of celebrity endorsements and social influencers to promote pod-based e-cigarettes should be further investigated by the FDA and actions to prevent youth exposure to this form of marketing, including a complete ban, should be considered.<sup>53</sup>

Second, restrictions on pod-based e-cigarette product design and youth access should be strengthened. These devices' high nicotine content and concealable design have attracted youth. In addition, while not unique to pod-based products, flavors such as mint, fruit, and dessert flavors are reasons for youth use.<sup>18,19,42,54,55</sup> Therefore, product design standards that impose restrictions on product flavor and styling that has greater appeal for youth than adults should be considered by state and federal regulators. Stronger restrictions on retail

sales to minors are needed, including rigorous age verification of online sales, and loopholes that allow on-selling via web-based retailers closed by closer surveillance and enforcement of state and federal laws. Notably, JUUL has recently placed certain restrictions on the sale and marketing of its products, including the removal of flavors, such as mango and crème, sold at store-based retailers, an enhanced age verification system,<sup>56</sup> and the removal of all broadcast, print, and digital advertising.<sup>57</sup> Similar approaches should be applied to all vaping products through the adoption of formal regulations. While the FDA has demonstrated progress in restricting youth sales, including issuing warnings to e-cigarette retailers,<sup>9</sup> further progress is needed, including coordination with state and local authorities to achieve greater surveillance and impose stronger penalties. Increasing the legal age of sale of all tobacco products, including vaping products, to 21 years is a highly effective measure to reduce youth use.<sup>58</sup> Youth are more price sensitive than adults<sup>59</sup> and therefore excise taxes that align with best practice tobacco control strategies (ie, excise taxes comprising 75% of the total product cost)<sup>60,61</sup> should also be implemented.

Finally, health communications that highlight the risks of pod-based e-cigarettes must also be leveraged. Health communications should aim to lower the current high social acceptability of pod-based products among youth<sup>2,17,19</sup> and communicate information about the presence and effects of high nicotine doses in pod-based products.<sup>26,29,31</sup> Youth may be more responsive to communications that focus on the risks and consequences of nicotine dependence, a more immediate outcome than disease risks that are temporally distant and may be less likely to arise than with smoking. Some progress has been made with the FDA enforcing a requirement for e-cigarette manufacturers to include warnings of nicotine addictiveness on product packages and advertisements beginning in 2018.<sup>62,63</sup> Social media has not been widely used by public health agencies to reach young people with appropriate health information regarding pod-based e-cigarettes, although the FDA and other organizations, including Truth Initiative, have disseminated youth-targeted health communications to prevent pod-based e-cigarette use among young people.<sup>64–67</sup> We recommend wider use of social media communications by public health entities to effectively reach adolescent populations with corrective health information and countermarketing communications.

### Gaps in Research

A growing body of evidence entails research gaps. Research on pod-based e-cigarette products has focused mostly on JUUL, yet this segment is rapidly growing and competitor products are expanding and evolving. The range of new products, their design and performance characteristics, and approach to marketing must be assessed, preferably using a standardized framework.<sup>68</sup> The goal of research on new products must be to understand factors that promote appeal to youth to identify targets for regulation. For example, the considerable public concern about the role of flavors in promoting adolescent vaping is reflected in the current findings<sup>17,30</sup> and encourages further research on how flavors are associated with use behaviors. We found only 1 qualitative study on pod-based e-cigarette use, which may be a source of insights on youth attitudes, motives, and preferences around them. Further research is needed to assess perceptions of product appeal, benefits, and health risks and determine how these measures are associated with future intentions to use and



actual use. Likewise, research is needed to assess the association of online/social media marketing with young peoples' future intentions to use. In addition, there was only 1 longitudinal study that examined pod-based e-cigarette use overtime.<sup>24</sup> Further studies with longitudinal designs will be able to answer important questions about the health risks of long-term exposure to harmful constituents, albeit at lower levels than in cigarettes, among youth. Additionally, we identified no studies that include parental knowledge or perceptions of pod-based e-cigarettes use among their children. A deeper understanding of parents' attitudes will help inform interventions that target youth through better communication with their parents. Finally, the available data do not allow conclusions as to whether pod-based e-cigarettes have the potential to produce serious lung injuries that have been reported in the US in recent months.<sup>69</sup> Early indications suggest that these injuries are associated with a history of using modifiable e-cigarette products that contain tetrahydrocannabinol or cannabidiol oils.<sup>70</sup> Further research will be needed to understand whether this risk applies also to pod-based nicotine e-cigarettes.

### Limitations

This review necessarily draws on a limited evidence base consisting of a relatively small number of peer-reviewed published studies; research under way at or before publication and gray literature have not been included and may have biased results. These studies represent a wide range of research aims and approaches, and so the available evidence on each of the 4 major areas is further limited.

### Conclusions

This review on pod-based e-cigarettes highlights the need for regulatory action to prevent youth from using these devices. Pod-based e-cigarettes deliver a high nicotine dose in a manner that is easy to consume and is marketed to reach and appeal to youth audiences. Strategies to prevent vaping among youth who have never smoked should continue to be sought and implemented. These findings suggest that restrictions on marketing through channels accessible to youth, restrictions on product designs that promote appeal among youth, and more rigorous restrictions on youth retail access and opportunities to use should be prioritized. Dissemination of health warnings that address knowledge deficits on the risks of vaping, especially the risk of nicotine dependence, and the implementation of state excise taxes should also be prioritized to prevent pod-based product uptake among youth.<sup>61</sup> More future research is needed to better understand the association of pod-based e-cigarette characteristics with youth perceptions of risk and appeal and design effective communication interventions to dissuade use among young people.

### Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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### Key Points

**Question**

What are the factors associated with use of pod-based electronic cigarettes (e-cigarettes) and their potential association with youth and young adult health?

**Findings**

In this systematic review, pod-based e-cigarettes enhanced the delivery of nicotine and had greater dependence potential. Youth and young adult use can be attributed to social acceptability, convenient product features, and aggressive social media marketing.

**Meaning**

Health communications and restrictions on social media, marketing channels, product design, and youth access are needed to prevent youth uptake of pod-based e-cigarettes.

**Table.****Summary of Findings and Policy and Research Recommendations**

<b>Summary of findings</b>	<b>Policy and research recommendations</b>
<b>Product design and biological effects</b>	
Pod ecigs deliver high doses of nicotine.	Health risks of nicotine dependence must be clearly communicated to youth and young adults.
Adolescents using pod ecigs are exposed to high levels of nicotine.	
Pod ecigs have a higher potential for dependence compared with other e-cigarettes.	
Pod ecigs have lower toxicants compared with other e-cigarettes and cigarettes.	
<b>Marketing</b>	
Pod ecig sales have increased rapidly and the brand JUUL has prioritized social media marketing.	Product design standards should impose restrictions on product features (eg, nicotine content, stealth features).
The advent of pod ecigs has spurred the growth of other e-cigarettes with high nicotine levels and stealth features.	Rigorous age verification of online sales is needed.
Regulations on pod ecig online marketing have been less successful.	Loopholes that allow sales via web-based retailers should be closed. Research is needed to assess whether exposure to social media marketing of pod ecigs leads to its use or intention to use.
<b>Social media communication</b>	
Positive and negative sentiments toward pod ecigs are found on social media outlets, such as Twitter and Reddit.	Direct marketing channels that reach youth should be banned.
JUUL is popular on Twitter and JUUL company tweets get retweeted by young people.	Indirect marketing through social media, celebrities, and social media influencers should be restricted.
Experiences using pod ecigs were discussed frequently on social media.	Government and anti-tobacco institutions should communicate the risks of pod-based e-cigarettes.
JUUL's official Instagram account featured lifestyle appeal.	
There is limited or moderate discussion about pod ecigs as a smoking cessation device or health risks of pod ecigs.	
<b>Population use and perceptions</b>	
Youth and young adult ever use of JUUL ranged from 9.5% to 11.2%.	Research should be expanded to include pod-based e-cigarettes other than JUUL.
JUUL users tended to be white and of higher socioeconomic status.	Reasons for using pod-based e-cigarettes and perceptions of them should be quantitatively and qualitatively assessed.
Pod ecig users tend to dually use other tobacco products.	Longitudinal studies are needed to assess the over-time risk and benefits of using pod ecigs.
Common reasons for using pod ecigs were social acceptability and convenient features of the product.	Parents' knowledge and perceptions of pod-based e-cigarettes should be assessed.
There is limited awareness of JUUL's nicotine content.	

Abbreviations: E-cigarettes, electronic cigarettes; pod ecigs, pod-based electronic cigarettes.