
Original Investigation

Prevalence of Young Adult Vaping, Substance Vaped, and Purchase Location Across Five Categories of Vaping Devices

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Abstract

Introduction: The rapidly evolving landscape of vaping devices has complicated analyses of use patterns among youth and young adults. The current study describes the prevalence of use, substances vaped, and purchasing behaviors across five different vaping device categories.

Aims and Methods: Participants ($n = 2505$; mean age = 19.2, SD = 0.46) from a cohort in the Los Angeles area completed web-based surveys from June 2018 to October 2019. For each of four device type categories depicted via digital images (any pod-style vape, cigalike, box-mod, vape pen) and for JUUL specifically, participants reported ever and past 30-day use, substance vaped (mostly nicotine, nicotine and tetrahydrocannabinol [THC], mostly THC, neither), ownership of device (yes/no), where they obtained that device (eg, purchased themselves, from a friend), and if purchased, purchase location (eg, vape shop, online).

Results: Overall, 44.9% reported ever use, and 26.2% reported past 30-day use of at least one of the devices. The prevalence of past 30-day use was highest for pod-style vapes (any pod = 17.0%; JUUL = 15.1%). Among respondents who reported ever owning any device ($n = 643$ [25.7%]), 59.9% reported purchasing the device themselves, despite not being of legal purchasing age (15.4% of total sample); across all device types, products were most often purchased in vape shops or online.

Conclusions: Across all devices, the prevalence of self-purchase of vaping devices among underage young adults in the Los Angeles area was high, and most were purchased from a vape shop or online. Tobacco control policies to prevent underage purchase of tobacco products—particularly among never smokers—are needed.

Implications: A high proportion of underage young adults reported owning their own vaping device and having purchased it themselves from a vape shop or online. Stronger tobacco control policies and better enforcement efforts are needed to successfully prevent underage purchase of tobacco products.

Introduction

There have been several generations of devices used to vape nicotine and tetrahydrocannabinol (THC) introduced to the market over the past decade, each of which have distinct features that

may influence the appeal, use patterns, and health effects of vaping.¹⁻³ The rapidly evolving landscape of vaping devices has made it difficult for researchers to accurately monitor patterns of vaping in the adolescent and young adult (AYA) population.⁴⁻⁶

First generation devices (ie, “cigalikes”) were designed to mimic the look and feel of combustible cigarettes and serve as a replacement for or complement to combustible cigarettes. Second generation devices (ie, “vape pens”) are characterized as “tank systems” that include larger rechargeable batteries and transparent cartridges that can be filled with separately purchased e-liquids. Third generation devices (ie, “mods” or “box-mods”) include highly customizable products that feature a large rechargeable battery, capable of providing customized power settings (eg, temperature or voltage-variable), with very high upper limits on the power output of the device.⁷ The most recent addition to the vaping device market include pod vape devices, which are characterized by their sleek design and flavor pods which use high-concentration salted nicotine formulations and emit very high levels of nicotine at low power output.² JUUL is the best-known brand name among this type of products.^{8,9} Given the challenges inherent in monitoring the prevalence of use in a rapidly changing vaping device market, the 2018 National Academies of Science, Engineering, and Medicine (NASEM) report on vaping devices among youth and young adults has recommended monitoring patterns of vaping in detail by assessing the type of device used.⁷

It is important to consider that different devices may uniquely impact patterns of behavior and subsequent differential health risks. For example, devices that contain higher levels of nicotine in a salted nicotine formulation (which minimizes the adverse sensory effects inherent to use of highly concentrated nicotine)^{10,11} may increase the likelihood of continued use, risk of the development of nicotine dependence, and subsequent health effects resulting from continued nicotine use and other toxins in e-cigarettes.¹² Recent findings indicate that use of later generation devices (eg, box-mods and pod vapes) is more common among AYAs than use of early generation cigalike devices¹³; compared with vape pens, box-mod devices predict greater combustible cigarette use among young adults.¹⁴ The latest generation of devices have introduced salted nicotine formulations (which minimize the adverse sensory effects inherent to use of highly concentrated nicotine)^{10,11} and may be more adaptable for use with different substances; for example, certain pod vape products are compatible with both nicotine and THC solutions.^{15,16}

Different devices might be more accessible at different purchase locations, such as vape shops, gas stations, or online retailers,^{3,17,18} or through social sources, such as friends.¹⁹ Previous research suggests that individuals who purchase vaping devices from vape shops and online retailers, as opposed to gas stations, pharmacies, or grocery stores, had greater odds of being daily users.²⁰ Further evidence suggests that regulation of the purchase and sale of vaping devices to minors has been insufficient in preventing youth access, especially at vape shops.^{21,22}

In the current study, we examined the prevalence of use, substance(s) vaped, and purchase behaviors separately across four categories of vaping devices and for JUUL, specifically, among young adults recruited in Southern California, utilizing images of different device types in the survey to increase accuracy of responses to questions.

Methods

Data Collection

This study utilized data from the most recent wave of the Happiness & Health Study (H&H), a prospective cohort of youth recruited in 2013 when they were in 9th grade at one of 10 high schools in the Los

Angeles metropolitan area that participated in the study. Participants were surveyed every semester through the end of high school (8 waves; 2013–2017) and subsequently resurveyed via online questionnaire after graduating from high school (Wave 9). Data from Wave 9 were collected from June 2018 to October 2019 ($N = 2548$; 81.0% retention from Wave 8 and 75.0% retention from initial enrollment in 2013). Analyses in the current study were restricted to participants who were under 21 at the time of survey (ie, to whom the sale of tobacco products was not legal; $N = 2505$; 98.4% of the sample). Participants were remunerated \$45 upon completion of the survey.

Ethics Statement

This study was approved by the University of Southern California Institutional Review Board; informed consent was obtained from all participants (at age 18 or older) prior to data collection.

Measures

E-cigarette Device Images

Participants were shown unique images of four categories of vaping devices, and an image of a JUUL (a type of pod-style vape). Categories included: any type of pod vape (multiple types of pod-style vaping devices, including JUUL), cigalikes, box-mods (multiple styles shown), and vape pens (multiple styles shown); an additional image with a photo of a JUUL was also shown separately (5 total images). For each image, participants were asked a series of questions pertaining to use and purchasing behaviors (see below).

Patterns of E-cigarette Use

For each image, participants were asked: “Have you ever used a product that looks like this?” Response options included: “Yes, in the past 30 days,” “Yes, but not in the past 30 days,” and “No.” Respondents who selected “Yes” (via either response) were considered to be “ever users” of that category of products (or of JUUL). Respondents who selected “Yes, in the past 30 days” were classified as “Past 30-day users.” We also created a composite variable across all four device categories and JUUL for both ever and past 30 day use, where “yes” indicated those who had used any of the products depicted in any of the images (ever or in the past 30 days, respectively), and “no” indicated that none of the products had been used (ever or in the past 30 days, respectively).

Substances Vaped

Participants who reported ever using a device in a given category were asked a follow-up question about substances they vaped in that device: “When you vaped this device, what substances did you vape?” Response options included: (1) Always nicotine, (2) Mostly nicotine and sometimes THC or hash oil, (3) Equal nicotine and THC or hash oil, (4) Sometimes nicotine and mostly THC or hash oil, (5) Always THC or hash oil, and (6) E-liquid or juice with no nicotine. For the present analyses, we collapsed these response categories into the following groups: (1) always nicotine, (2) nicotine & THC (mostly nicotine, nicotine and THC, and mostly THC), (3) always THC, and (4) neither nicotine nor THC.

Purchase Behaviors

For each device or device category, participants were asked whether they had ever owned one of those devices. Participants who reported ever owning a device in a given category (or a JUUL, separately) were asked follow-up questions on how they obtained the device.

Response options for the question “Where did you get this device?” included (select all that apply): someone gave it to me, stole it, found it, took it from a family member, someone else purchased for me, purchased myself, other method.

Individuals who responded “purchased myself” were asked an additional follow-up question on where they purchased the device. Response options included (select all that apply): online brand retailer, eBay, Craigslist, Facebook, somewhere else online, vape shop, tobacco specialty shop, grocery store, pharmacy, gas station, and from a friend. Due to very low prevalence of purchasing from eBay, Craigslist, Facebook, and somewhere else online for each device, these categories were collapsed with “online brand retailer” into one category for analysis (“Online”). Gas stations, grocery stores, and pharmacies similarly were collapsed into one “Other” category due to low prevalence.

Sociodemographic Factors

Sociodemographic variables were collected via self-report. Participants were asked about their gender identity (male/masculine, female/feminine, or other), sexual orientation (bisexual, gay/lesbian, straight, or other), and whether they identified as Hispanic or Latino (yes/no). Race was assessed with “select all that apply” response options: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, White, Multiracial, or Other. Both childhood and current subjective financial situation were assessed.²³ Responses for childhood subjective financial situation included: poor, average, well off, and it varied. Responses for current subjective financial situation included: do not meet basic expenses, just meet basic expenses, meet needs with a little left, and comfortable. Age was collected in whole numbers as years, with valid response options ranging from 18 to 20. Education was assessed by asking respondents whether they were currently enrolled in a degree program (yes, no, don't know).

Statistical Analyses

In descriptive analyses, we calculated the prevalence of use of each device or device type category (ever use, and past 30-day use, separately) among all participants in the analytic sample. Then, we calculated the prevalence of ever owning a device among those who reported ever use of that device or device type category. The prevalence for each method of obtaining a device was calculated among participants who reported ever owning a device. Prevalence estimates of purchase at each location were calculated among those who reported ever having purchased a product themselves. [Supplementary Figure 1](#) provides additional data regarding the survey flow and resulting sample sizes by device or device category. All frequencies and percentages were estimated using SAS v 9.4.

Results

Sample Characteristics

The sample had more females than males (56.6% vs. 40.9%) and more than half identified as Hispanic or Latino (55.5%; [Table 1](#)). The most common racial categories included White, Asian, and Multiracial (33.3%, 24.2%, and 20.4%, respectively). Among all participants, 80.7% identified as heterosexual. The mean age was 19.2 (SD = 0.46). A majority of participants (65.4%) were currently enrolled in degree programs. Although 51.7% reported average subjective financial situations during childhood, 45.1% reported living comfortably at the time of the current survey.

Table 1. Demographic Characteristics and Vaping History of Participants, *N* = 2505

Variable	<i>N</i>	%
Gender identity		
Male/masculine	971	40.9
Female/feminine	1343	56.6
Other ^a	58	2.5
Race ^b		
American Indian or Alaska Native	130	5.4
Asian	586	24.2
Black or African American	178	7.3
Native Hawaiian or Pacific Islander	107	4.4
White	806	33.3
Multiracial	494	20.4
Other	489	20.2
Hispanic or Latino		
Yes	1344	55.5
No	1078	44.5
Sexual orientation		
Bisexual	193	8.2
Gay/lesbian	62	2.6
Heterosexual	1897	80.7
Other ^c	200	8.5
Current subjective financial situation		
Don't meet basic expenses	125	5.3
Just meet basic expenses	497	21.2
Meet needs with a little left	666	28.4
Comfortable	1056	45.1
Childhood subjective financial situation		
Poor	352	15.0
Average	1213	51.7
Well off	513	21.9
It varied	270	11.5
Currently enrolled in a degree program		
Yes	1540	65.4
No	667	28.3
Don't know	149	6.3
Age (years)		
18	46	1.8
19	1917	74.3
20	616	23.9
Ever vaped any device	1174	44.9
Past 30-day use of any device	660	26.2
Ever owned any device ^d	643	25.7
Purchased device themselves ^e	385	15.4

^aOther includes: trans male, trans female, gender variant or non-binary, and other.

^b“Select all that apply” categories are not mutually exclusive and may not add to 100%.

^cOther includes: asexual, pansexual, queer, questioning or unsure, and other/prefer not to say.

^dThis question was only asked to respondents who reported ever using any device (*n* = 1174).

^eThis question was only asked to respondents who reported ever owning any device (*n* = 643).

Prevalence of E-cigarette Use

44.9% of the sample (*n* = 1174) reported lifetime use of at least one of the five device types, and 26.2% (*n* = 660) reported past 30-day use of at least one of the five device types. The prevalence of ever use was highest for pod-style vaping devices (ie, any pod device, JUUL [34.8% and 32.8%, respectively]; [Figure 1](#)) and lowest for cigalike devices (11.8%). Similarly, the prevalence of past 30-day use was

highest for pod-style vaping devices (any pod-type device = 17.0%; JUUL = 15.1%) and lowest for cigalike devices (2.3%). There was overlap in the categories of products used among participants (see [Supplementary Table 1](#)).

Substances Vaped

Nicotine was the most commonly reported substance vaped in JUUL, pod vape, cigalike, and box-mod devices (59.8%, 51.8%, 43.7%, and 63.1%, respectively) compared with 13.5% for vape pens; the most commonly reported substance used in vape pens was THC (52.2%; [Figure 2](#)). Box-mods had the highest rates of vaping only flavored e-juice (ie, no nicotine or THC) and JUUL had the lowest rates of vaping only flavored e-juice (21.4% vs. 9.4%, respectively).

Methods for Obtaining Devices

Among those who reported ever owning a device ($n = 643$, 54.8% of those who had ever used any e-cigarette device; 15.4% of the total sample), the most common method for obtaining a vaping device

was by purchasing themselves (59.9%, [Table 1](#); [Figure 3](#)). Very low rates (<5.0%) were observed across all five device types for “found it,” “stole it,” “took it from family,” and “other method.”

Purchase Behaviors

Among respondents who reported purchasing their devices themselves ($n = 385$, 59.9% of those who owned a device), online and vape shops were the most commonly reported purchase locations ([Figure 4](#)). Across all five devices, grocery stores and pharmacies were the least common purchase locations (all <5.0%).

Discussion

This study provides critical information concerning the prevalence of use, substances vaped, and purchasing behaviors across five different types of vaping devices. Nearly half of the sample had ever used a vaping device and a quarter reported past 30-day use of at least one of five commonly used vaping devices. Overall, nicotine

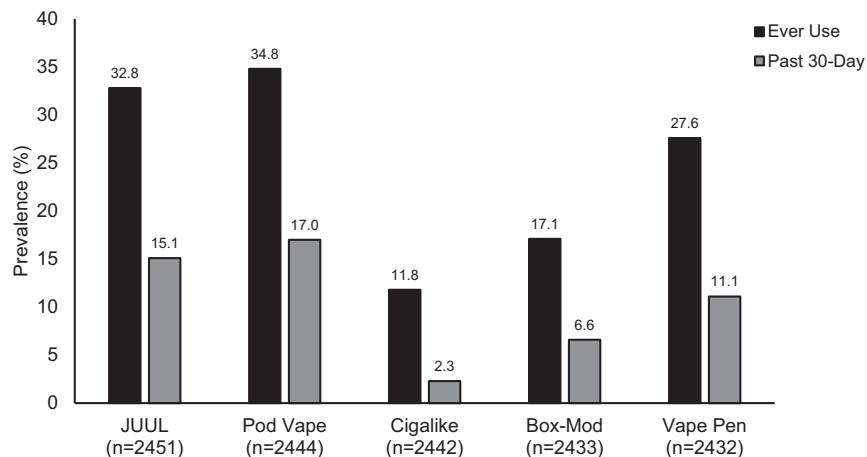


Figure 1. Prevalence of ever and past 30-day use by device or device type category. Prevalence estimates based on presentation of five separate device type images asked to all survey respondents. Total sample size varies based on missing data. Ever users are those who reported ever using the device but not in the past 30 days. Past 30-day users reported using the device in the past 30 days. Past 30-day and ever user groups were not mutually exclusive, such that the ever user group also includes past 30-day users.

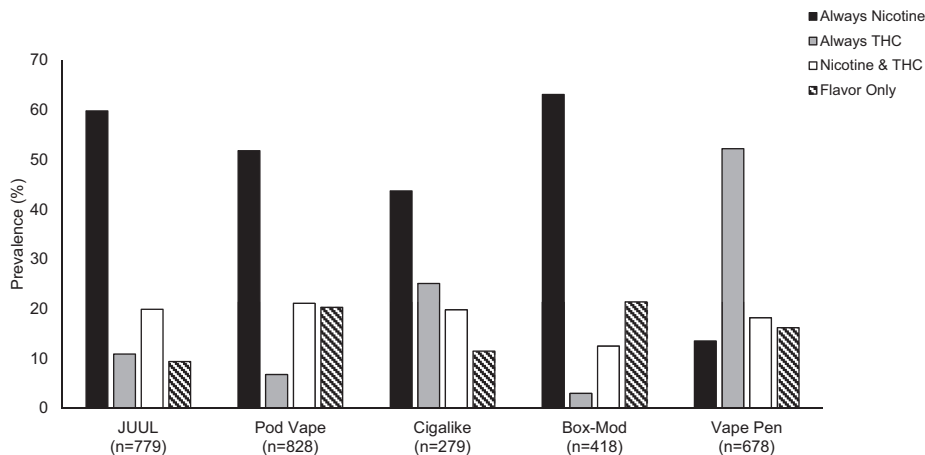


Figure 2. Substances vaped by device or device type category. Prevalence estimates based on presentation of device type images asked to survey respondents who reported ever use of the device. “Always nicotine” includes those who indicated always vaping nicotine. “Always THC” includes those who indicated always vaping THC. “Nicotine & THC” includes those who indicated vaping mostly nicotine, mostly THC, or nicotine and THC. “Flavor only” includes those who indicated vaping neither nicotine nor THC (i.e., just flavored e-juice).

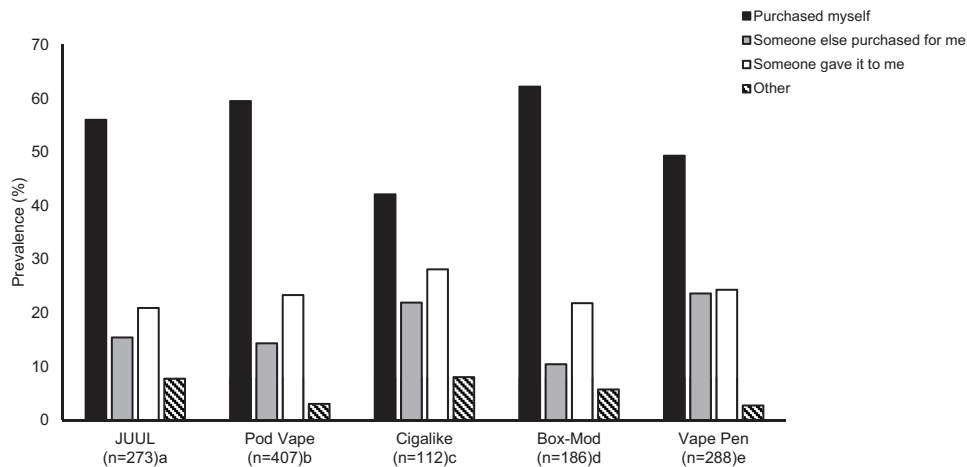


Figure 3. Method of obtaining product by device type. Prevalence estimates based on presentation of device type images asked to survey respondents who reported owning the device. Participants could select multiple methods of obtaining a given device so estimates by method do not total to 100%. ^aOther: found it (4.0%), stole it (0.4%), took it from family (2.2%), other method (1.1%). ^bOther: found it (1.5%), stole it (1.0%), took it from family (0.0%), other method (0.5%). ^cOther: found it (3.5%), stole it (1.8%), took it from family (1.8%), other method (0.9%). ^dOther: found it (2.1%), stole it (1.0%), took it from family (1.6%), other method (1.0%). ^eOther: found it (0.3%), stole it (0.3%), took it from family (1.4%), other method (0.7%).

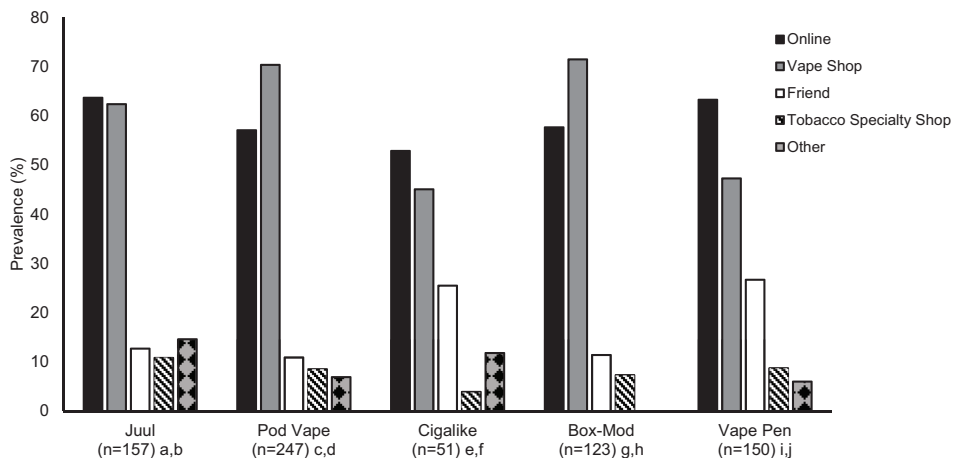


Figure 4. Purchase location by device type. Prevalence estimates based on presentation of device type images asked to survey respondents who reported purchasing the device themselves. Participants could select multiple methods of obtaining a given device so estimates by method do not total to 100%. ^aOnline: online brand retailer (56.2%), eBay (0.0%), Craigslist (0.0%), Facebook (0.0%), somewhere else online (2.1%). ^bOther: gas station (12.7%), grocery store (1.9%), pharmacy (0.0%). ^cOnline: online brand retailer (49.8%), eBay (6.0%), Craigslist (0.0%), Facebook (0.0%), somewhere else online (1.3%). ^dOther: gas station (6.1%), grocery store (0.0%), pharmacy (0.0%). ^eOnline: online brand retailer (51.1%), eBay (2.1%), Craigslist (0.0%), Facebook (0.0%), somewhere else online (4.3%). ^fOther: gas station (9.8%), grocery store (0.0%), pharmacy (2.0%). ^gOnline: online brand retailer (54.3%), eBay (4.3%), Craigslist (0.0%), Facebook (0.0%), somewhere else online (1.7%). ^hOther: gas station (0.0%), grocery store (0.0%), pharmacy (0.0%). ⁱOnline: online brand retailer (53.8%), eBay (5.6%), Craigslist (0.7%), Facebook (0.0%), somewhere else online (2.8%). ^jOther: gas station (1.3%), grocery store (0.0%), pharmacy (4.0%).

was the most commonly vaped substance, but findings suggest that vape pens were mostly used to vape THC in this sample of young adults. Purchasing behaviors remained relatively consistent across device types; approximately 60% of those who had ever owned an e-cigarette had purchased an e-cigarette device themselves, and had done so most commonly at a vape shop or online.

We found that nearly half of those who had ever used either a JUUL or any pod-style device also reported past 30-day use, which is consistent with previous work.²⁴ JUUL (and similar pod vape devices) often use a salted nicotine formulation (vs. cigalike and box-mod devices, which usually use free-base nicotine), which allows for a substantially higher concentration of nicotine without the adverse sensory effects found in high concentrations of freebase nicotine.^{5,25}

Future research might assess differential risks for nicotine dependence and relative abuse liability.²⁶

Substances vaped might vary by device type. Out of the four device categories (and JUUL, independently) compared in this study, vape pens were more commonly used for vaping THC than for vaping nicotine. Future research should distinguish between “vaping nicotine” and “vaping cannabis/THC” to avoid conflating two different substances that are commonly vaped and may have very different health consequences. Moreover, previous literature suggests that many vapers are unaware of whether or not they are using nicotine (and may incorrectly report using no nicotine or THC when they are using nicotine),¹⁰ so the true prevalence of nicotine vaping among ever users in this sample may be higher.

In 2016, California implemented a state-wide Tobacco 21 policy, which raised the legal age of sale of all tobacco products—including vaping devices—to 21 years of age, in an effort to prevent tobacco use initiation among youth.²⁷ All of the participants in the current study were under the age of 21 at the time of the survey, and thus were unable to legally purchase tobacco products (including vaping products). However, the majority of participants who owned a vaping device reported that they purchased devices themselves, and that they had primarily purchased their products from vape shops or online; grocery stores, gas stations, and convenience stores were the least common purchase locations. It is possible that vape shops and online retailers were more popular among this sample because of their relatively extensive inventory or variety of vaping products or because of less vigorous age verification methods.²⁸ Previous research has found that tobacco retail licensing may decrease vaping initiation, but only in areas with strong local enforcement policies.²⁹ Given our findings that vape shops were one of the most common purchase locations, increasing licensing fees to fund enforcement of tobacco retail policies has the potential to greatly reduce vaping by minors.

This study has limitations. The order of the five images presented to respondents were not randomized, thus, respondents may have been subject to priming effects, such that seeing an image of a JUUL first may have affected how they responded to subsequent device type images. Additionally, considering the rapidly evolving vaping device product markets, it is unclear whether these five images accurately represent all device categories (eg, we did not assess disposable pod devices, which were not available at the time of survey development but entered the marketplace while we were collecting data); it is possible that other devices not included in the survey images were used and therefore not reflected in these data. There was substantial overlap between device type categories in the presentation of images describing each, thereby complicating interpretations of between device type differences. Nevertheless, the findings presented herein suggest the importance of further research differentiating category of device used, particularly regarding the substance consumed in a given vaping product. More fine-grained categories of product may also be useful in determining whether the purchasing behaviors observed in this study extend to newer products, or are specific to a given brand or more distinct type of vaping product.

Conclusions

Preventing tobacco use by AYAs remains a regulatory challenge that is often complicated by a rapidly evolving product landscape, with new vaping devices and corresponding novel nicotine and THC e-liquid formulations frequently appearing in the market. Understanding how different device types and their respective nuances contribute to the prevalence rates of vaping among young people can help identify policy needs and facilitate changes to improve public health. Our findings highlight that an appreciable proportion of underage young adults have owned an e-cigarette device, purchased that device themselves, and purchased the product either online or from a vape shop. Enforcement efforts to reduce underage purchase of tobacco products are needed.

What's Known on This Subject

The prevalence of vaping among youth and young adults remains high, and there are a wide variety of vaping devices used. Differences in prevalence, substances vaped, and purchase behaviors across devices are not known.

What This Study Adds

A high proportion of underage young adults reported owning their own vaping device and having purchased it themselves from a vape shop or online. Stronger tobacco control policies and better enforcement efforts are needed to successfully prevent underage purchase of tobacco products.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at <https://academic.oup.com/ntr>.

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Declaration of Interests

None declared.

Authors' Contribution

Ms Sam Cwalina formulated the research question, conducted statistical analyses, interpreted the results, wrote and edited the manuscript, and approved the manuscript as submitted. Drs Braymiller, Leventhal, Unger, and McConnell contributed to editing the manuscript and approved the manuscript as submitted. Dr Barrington-Trimis contributed to formulating the research question, interpretation of results, and to editing the manuscript, and approved the manuscript as submitted.

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