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Types of electronic nicotine delivery systems (ENDS) used by people of different age and smoking status groups: results from a US nationally representative survey

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ABSTRACT

Objectives The type of electronic nicotine delivery system (ENDS) used by different age groups may be associated with ENDS and cigarette use behaviours. This study sought to identify differences in the use of ENDS device type based on age and cigarette use status to inform policy about regulating ENDS.

Design This was a cross-sectional study.

Setting Data was derived from a national survey conducted in 2021 in the USA.

Participants Participants include 2369 US youth and adults (13 years or older) who reported past 30-day ENDS use.

Outcome measures Past 30-day fairly regular use (i.e., several times a week or more) of ENDS device types, namely cigalikes, disposables, refillable tank/box mods, closed pods, refillable pods and drippers. Cigarette smoking status was also measured.

Results We used weighted regression models to determine the association between ENDS device type current regular use and age group and the association between each ENDS type current regular use and smoking status separately for each age group. Youth ENDS users 13–17 years old were more likely to regularly use cigalikes (OR=2.71), disposables (OR=3.44), closed pods (OR=2.57) and drippers (OR=2.86) and 18–29 years old were more likely to regularly use disposables (OR=3.67), closed pods (OR=1.58) and drippers (OR=1.94), compared with 30+ years old ENDS users (all p<0.05). Among 13–17 years old, current (vs never) smokers had greater odds of current regular use for cigalikes (OR=2.79), disposables (OR=2.33), refillable tanks (OR=2.27), closed pods (OR=2.62) and drippers (OR=6.32; all p<0.05). Similarly, 18–29 years old current (vs never) smokers had higher odds of reporting current regular use of refillable tanks (OR=1.80), refillable pods (OR=2.63), closed pods (OR=2.20) and drippers (OR=4.89; p<0.05).

Conclusions Both age and smoking status were associated with current regular use of ENDS, especially for youth and young adults. These findings inform regulatory agencies as they monitor and enforce policy on ENDS allowed on the US market.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study collected a large, nationally representative sample of youth and adults.
⇒ The survey assessed self-reported use of a wide range of electronic nicotine delivery systems (ENDS) and differentiated between different types of ENDS devices used.
⇒ Quality assurance checks were used in the design (e.g., asking for qualitative descriptions of ENDS used), and open-ended responses to questions were manually coded for accuracy.
⇒ Participants were online survey panelists and their beliefs, attitudes and behaviours could be affected by prior survey studies they have completed.
⇒ The survey was collected in 2021 and may not reflect ongoing evolution of ENDS device types, recent U.S. Food and Drug Administration (FDA) marketing decisions, and current regulation of ENDS.

INTRODUCTION

Electronic nicotine delivery systems (ENDS) are a common way for youth and adults to use nicotine in the USA and worldwide.[1–3] The term ENDS describes a diverse class of devices sharing the same basic design in which a battery-powered coil heats and aerosolises a liquid (called e-liquid) containing vegetable glycerin, propylene glycol, and/or other chemicals, usually nicotine and flavourings.[4–6] Data from the US National Youth Tobacco Survey (NYTS) showed that in 2022, ENDS were the most commonly used tobacco product among youth (grades 6–12).[7] Similarly, 2020 US National Health Interview Survey (NHIS) data showed that ENDS were the most commonly used tobacco

product for young adults (18–24 years old) and second most for 'other' adults outside young adulthood (25–64 years old).[8]

Youth uptake of ENDS is concerning, given the well-documented associations between vaping and smoking among youth and young adults.[9–13] For example, according to NHIS data, the largest increase in vaping from 2014 to 2018 was among young adults (18–29 years old) who had never smoked.[14] Moreover, vaping increases for other adults (30+) primarily among those already smoking but trying to quit.[14] Comparatively, NYTS data showed that youth (12–17 years old) began vaping at younger ages in 2018 than in 2014–2017. There were no comparable increases in initiating smoking (i.e., cigarettes, cigars and pipe tobacco) during that same time. These findings suggest that, from 2014 to 2018, youth were increasingly using ENDS as the initial step into nicotine use.[15] However, while some reports indicate that ENDS may be a pathway into nicotine use for youth,[15] other reports show that adults may use ENDS to quit smoking or use in places where smoking is not allowed.[16] Thus, different age groups may use ENDS differently, making the FDA's assessment of population health effects challenging.

Multiple device types which can differ in terms of attractiveness, abuse liability and toxicity raise an additional regulatory complication. ENDS may be designed to look like cigarettes (i.e., *cigalikes*) or tanks with refillable reservoirs and rechargeable batteries. Some are 'mods' with modifiable features (e.g., power controls), and other types include open and closed pod systems with rechargeable batteries (e.g., JUUL) or *disposable* devices meant to be used and discarded.[10 17–19] *Drippers* or *squonkers* allow users to drip liquids directly onto exposed heater coils manually, greatly increasing the amount of aerosol generated with each use[20–22] and potentially exposing users to increased toxicant emissions in vapours from the higher combustion temperatures of e-liquids.[23 24] Different ENDS device types have different risk profiles for nicotine and toxicant delivery, abuse liability, respiratory diseases and device-specific risks (e.g., battery explosions).[25] Youth, young adults and other adults might prefer different ENDS device types and the popularity trends might differ between age groups.[26] The variety of ENDS device types is a potential opportunity for regulations targeting specific device characteristics towards maximising benefits (e.g., smoking cessation) and minimising harms (e.g., minimising adoption among youth) of ENDS use. Relatedly, research should assess how different ENDS device types are associated with tobacco-use behaviours, including uses by different populations for different ENDS device types.

A better understanding of who is likely to use ENDS device types could inform future regulatory discussions around potential benefits and unintended consequences of ENDS use (e.g., device type ban or regulating a device/liquid characteristic commonly associated with a specific device). An important regulatory question is whether decisions about which ENDS device types to allow on the market may be used as a means of minimising youth uptake while encouraging smoking cessation among current smokers. To help address this question, we surveyed nationally representative samples of youth (13–17 years old), young adults (18–29 years old) and 'other' adults (30+ years old) living in the USA who reported using ENDS fairly regularly in the past 30 days and assessed associations between current regular use of six ENDS types (cigalikes, disposables, refillable tank/box mods, closed pods, refillable pods and drippers) with age and smoking status. The research was guided by two research questions. First, how does ENDS use differ by device type and age? Second, how is ENDS device type use associated with cigarette smoking within the age cohorts?

METHODS

Study sample and procedures

In 2021 (June–September), we conducted a national survey of 2369 US youth and adults (13 years or older) who reported past 30-day ENDS use. Survey participants were drawn from Ipsos' KnowledgePanel, a probability-based web panel designed to be representative of the USA and Ipsos opt-in panels. KnowledgePanel members are recruited through address-based sampling, and households are provided with access to the internet and computers if needed. Sampling of KnowledgePanel members was stratified by age: 13–17 years old, 18–29 years old and 30+ years old. To recruit the youth 13–17 years old sample, Ipsos used preidentified KnowledgePanel households with youth in the target age range and obtained both parental consent and youth assent before youth began the survey. A study-specific poststratification weight variable was computed using an iterative proportional fitting (raking) procedure to adjust for differential non-response. Age-stratified demographic distributions from the 2018–2019 Tobacco Use Supplement of the Current Population Survey (TUS-CPS) for adult participants (gender by age, race/ethnicity, region by metropolitan area status, education and household income) and from the 2020 NYTS for the 13–17 years old youth sample (namely, gender by age, race/ethnicity) were used. Participants from the opt-in panel were aligned with the KnowledgePanel sample using a calibration weighting process based on the aforementioned geodemographic distributions and a common set of attitudinal/behavioural measures asked of both samples that have been found to differentiate non-probability and probability samples.[27] Weights ranged from 0.21 to 4.48, with a median weight of 0.79 for the KnowledgePanel participants and 0.72 for the opt-in participants. Specific details of the survey weighting are provided in the online supplemental materials.

In the online survey, adult participants first provided informed consent. For youth, if their parents provided consent, the youth then provided assent before participating. After providing consent or assent, participants

answered demographic and substance-use questions, were shown images of ENDS device types and were asked to identify device types used (described in full in measures; see online supplemental material). Of the 2369 participants who qualified for and completed the survey, 202 cases were excluded prior to statistical weighting due to logical inconsistencies, data quality issues or completing the survey in less than 4 min. An additional 220 cases were excluded due to additional data quality issues (i.e., providing unintelligible or incorrect brand information) detected after statistical weighting, resulting in an analytical sample (n=1947) consisting of 817 KnowledgePanel (probability sample) and 1130 opt-in participants consisting of 553 youth (13–17 years old), 634 young adult (18–29 years old) and 760 other adult (30+ years old) participants. The median survey length was 21 min, and participants received a cash equivalent of US$5 for their participation.

Measures

These data are part of a larger project about ENDS modifications. Development of survey measures was guided by qualitative interviews with youth[28 29] and adults[30–32] who used ENDS. ENDS device types identified from these studies informed the ENDS device types included in the survey. We conducted cognitive testing of the survey prior to administration with 15 adult and 5 youth ENDS users to assess how they understood survey questions.

ENDS device type use

Participants were asked if they had ever used each of six ENDS device types (i.e., cigalikes, disposables, refillable tank/box mods, closed pods, refillable pods and drippers) fairly regularly (at least several times a week or more). Each ENDS device type was accompanied by prototypical images and definitions. For each ENDS device type used, participants were also asked if they had used that type of ENDS in the past 30 days *fairly regularly*. If they responded *yes*, they were asked to provide the brand and model of that type of ENDS that they currently use most often.

While reviewing responses for brand and model entered, we observed that some participants had misclassified their ENDS device type. To address this, each response for brand and model was reviewed independently by two research team members and classified as correct, cannot be determined ('don't know' or blank), or incorrect. Any disagreements were discussed and resolved. If a brand/model response was classified as incorrect, the response was subclassified as either incorrect ENDS device type, incorrect tobacco product (e.g., combusted cigarette brand), non-sensical or non-tobacco consumer product. Past 30-day use of an ENDS device type was changed from 'yes' to missing data if reported use could not be determined (ie, incorrect brand/model response). If the participant reported a brand/model of another type of ENDS (incorrect ENDS type), they were recoded as having currently used that other type of ENDS. ENDS device type use status was coded as 'current regular user' or 'not current regular user' (i.e., never used regularly or does not currently use regularly). ENDS device type use was further coded for current regular use of multiple ENDS device types.

Smoking status

To assess smoking status, participants were asked if they had ever tried cigarette smoking. If so, they were asked if they smoked at least 100 cigarettes in their life. Participants who answered in the affirmative were asked if they now smoked cigarettes some days, every day, or not at all. Established smoking status was trichotomised as never smoker (never smoked or had not smoked 100 or more cigarettes), former smoker (had smoked 100 or more cigarettes; currently not at all smoking) and current smoker (smoked 100 or more cigarettes; currently smoking on some days or every day).

Demographics

Demographics included age, gender, racial identification, ethnicity and education.

Analysis

Proportions for current regular use were calculated by ENDS device type and smoking status variables within each age group. We regressed current regular use status (vs. not current regular use) of ENDS on age group (30+ as reference) for each ENDS device type in weighted univariate logistic regression models. Additionally, we regressed current regular ENDS use status on smoking status ('never smoked' as reference) for each ENDS device type separately for each age group using weighted univariate logistic regression models. All analyses were conducted in SPSS (V.25), including the complex samples module for the weighted regression analyses.

Patient and public involvement

Patients and the public were not involved in the design, conduct, analysis or interpretation of the study. Study participants could have access to the study results on request.

RESULTS

Sample characteristics

Table 1 shows participant characteristics (n=1947). Youth (n=553; mean age=15.5; 52.2% female) mostly identified as white, non-Hispanic (51.5%), and the majority classified as never smokers (54.3%). For young adults (n=634; mean age=23.5; 62.3% male), most identified as white, non-Hispanic (72.8%), and most classified as current smokers (49.2%). The other adults (n=760; mean age=47.4; 55.3% male) identified mainly as white, non-Hispanic (80.4%) with the majority classified as former smokers (56.7%).

Current regular ENDS use

Figure 1 shows the percentage of current regular ENDS use by device type within age groups. Among youth, the

Table 1 Sample characteristics (n=1947; unweighted) by age group

	Youth (13–17 years old) n=553			Young adults (18–29 years old) n=634			Other adults (30+ years old) n=760		
	*N**	Estimate %†	95% CI	*N*	Estimate %	95% CI	*N*	Estimate %	95% CI
Age (mean)	553	15.5	15.3 to 15.6	634	23.5	23.2 to 23.9	760	47.4	46.4 to 48.4
Gender									
Male	287	47.0	42.5 to 51.5	353	62.3	57.2 to 67.1	319	55.3	50.9 to 59.6
Female	264	52.2	47.6 to 56.7	281	37.7	32.9 to 42.8	441	44.7	40.4 to 49.1
A different identity	2	0.8	0.20 to 3.30	.	0.0	.	.	0.0	.
Race/ethnicity									
White, non-Hispanic	358	51.5	46.9 to 56.1	433	72.8	68.0 to 77.2	614	80.4	76.6 to 83.7
Black, non-Hispanic	38	6.0	4.3 to 8.3	42	5.3	3.5 to 7.8	41	5.8	4.0 to 8.4
Other, non-Hispanic	20	4.8	3.1 to 7.5	30	3.9	2.4 to 6.3	18	3.4	2.0 to 5.5
2+races, non-Hispanic	35	9.0	6.4 to 12.5	29	3.9	2.3 to 6.5	19	3.0	1.7 to 5.1
Hispanic, Latina or Latino, or Spanish Origin	102	28.6	24.2 to 33.5	100	14.1	10.9 to 18.1	68	7.5	5.6 to 9.9
Education‡									
Less than high school	.	.	.	42	8.2	5.6 to 11.8	29	7.5	5.1 to 11.0
High school	.	.	.	237	39.8	34.7 to 45.2	151	31.0	26.7 to 35.8
Some college	.	.	.	200	37.1	32.0 to 42.5	330	40.1	35.8 to 44.4
Bachelor's degree or higher	.	.	.	102	10.4	7.9 to 13.4	149	12.3	10.2 to 14.7
Master's degree or higher	.	.	.	53	4.6	3.2 to 6.4	101	9.1	7.2 to 11.4
Smoked 100 cigarettes in lifetime									
Yes	170	45.7	40.1 to 51.4	360	68.6	62.6 to 73.9	696	94.4	91.9 to 96.2
Smoking status§									
Never smoker	184	54.3	48.6 to 59.9	145	31.4	26.1 to 37.4	38	5.6	3.8 to 8.1
Former smoker	9	2.7	1.3 to 5.4	88	19.3	14.8 to 24.8	421	56.7	52.2 to 61.2
Current smoker	161	43.0	37.5 to 48.7	272	49.2	43.3 to 55.2	275	37.7	33.4 to 42.2
Current use by ENDS device type¶									
Cigalike	156	30.7	26.4 to 35.3	131	16.1	12.7 to 20.1	107	14.0	11.2 to 17.5
Disposable	211	39.7	35.2 to 44.5	263	40.7	35.5 to 46.1	128	15.4	12.6 to 18.7
Refillable tank	207	37.4	33.0 to 42.1	227	38.2	33.1 to 43.7	341	48.5	44.0 to 52.3
Refillable pod	114	22.3	18.6 to 26.5	151	22.8	18.6 to 27.5	178	23.6	19.9 to 27.8
Closed pod	249	47.6	42.9 to 52.3	240	35.9	30.9 to 41.1	199	26.1	22.4 to 30.3
Dripper	92	16.1	13.1 to 19.8	89	11.5	8.8 to 15.0	45	6.3	4.4 to 8.9
Multiple ENDS device types**	275	48.2	43.6 to 52.8	292	41.4	36.3 to 46.7	240	29.6	25.7 to 33.8

*The *n*-size columns for each age group are unweighted.
†The estimate columns and CIs for the estimate percents are weighted.
‡Education for 13–17 years old measured grade level, whereas education for adults was measured from 'Some high school' to 'Master's degree or higher'.
§Established smoking status was coded as never smoker (never smoked or had not smoked 100 or more cigarettes), former smoker (had smoked 100 or more cigarettes; currently not at all smoking), and current smoker (smoked 100 or more cigarettes; currently smoking on some days or every day).
¶Current regular use of each ENDS device type was scored as follows: 0 = 'No, have not used device fairly regularly (at least several times a week or more) in the past 30 days' or 1 = 'Yes, used device fairly regularly (at least several times a week or more) in the past 30 days'. 'Refused to answer' responses were treated as missing in analyses.
**Current regular use of multiple ENDS device types was scored as follows: 0=Do not currently use devices listed in survey or only use a single listed ENDS type, or 1=Yes, currently use two or more of the listed ENDS types. Participants could identify multiple ENDS types so that participants who indicated they used two ENDS types (e.g., cigalikes and disposables) would be counted as a current regular user of cigalikes, disposables and multiple ENDS types.

most prevalent currently regularly used ENDS device type was closed pods (47.6%, 95% CI 42.9% to 52.3%); among young adults, disposables were most prevalent (40.7%, 95% CI 35.5% to 46.1%), and among other adults, it was refillable tanks (48.5%, 95% CI 44.0% to 52.3%). A large proportion of youth (48.2%, 95% CI 43.6% to 52.8%) and young adults (41.4%, 95% CI 36.3% to 46.7%) currently regularly used multiple ENDS device types. A smaller percentage of other adults (29.6%, 95% CI 25.7% to 33.8%) reported current regular use of multiple ENDS device types.

Weighted univariate logistic regression models compared age groups (other adults as reference) for current regular use of ENDS device type (vs. not) among all participants (see table 2). Youth had significantly higher odds of reporting current regular use of cigalikes

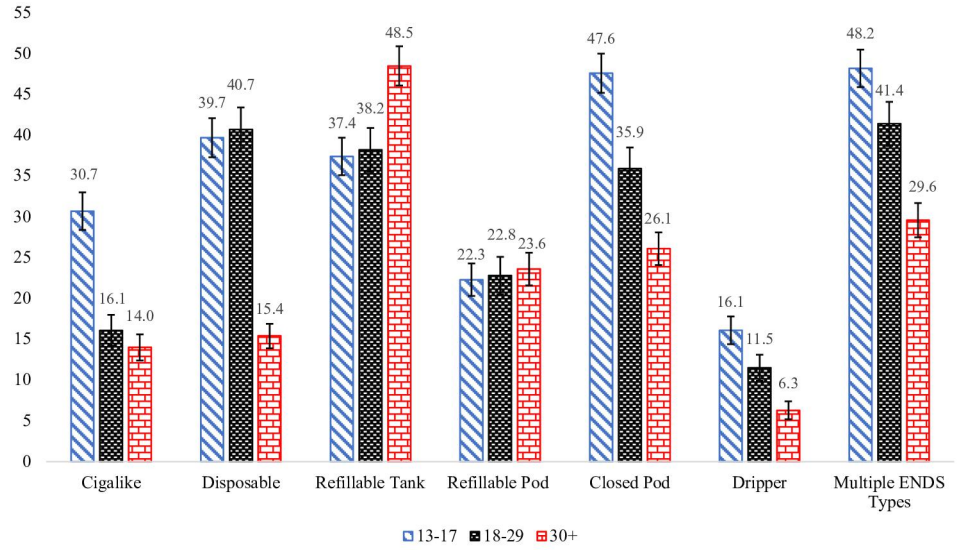

Figure 1 Percentages of current regular use of Electronic nicotine delivery systems (ENDS) device type by age group. Note: Y-axis is the percentage of current regular ENDS use by device type and within each age group. Percentages were calculated as current regular use of each ENDS device type out of all participants. Current regular ENDS use was coded if participants indicated they had (1) ever used the ENDS device type and (2) used that ENDs device type in the last 30 days. Participants could identify multiple ENDS device types so that participants who indicated they used two ENDS types (eg, cigalikes and disposables) would be counted as a current regular user of cigalikes, disposables, and multiple ENDS device types.

(OR=2.71, 95% CI 1.94 to 3.78), disposables (OR=3.44, 95% CI 2.55 to 4.64), closed pods (OR=2.57, 95% CI 1.94 to 3.40), drippers (OR=2.86, 95% CI 1.83 to 4.47), and multiple ENDS device types (OR=2.21, 95% CI 1.69 to 2.89) than other adults. Similarly, young adults had greater odds of reporting current regular use of disposables (OR=3.76, 95% CI 2.67 to 5.05), closed pods (OR=1.58, 95% CI 1.17 to 2.14), drippers (OR=1.94, 95% CI 1.20 to 3.13), and multiple ENDS device types (OR=1.68, 95% CI 1.26 to 2.25) than other adults. Notably, youth (OR=0.61, 95% CI 0.46 to 0.79) and young adults (OR=0.64, 95% CI 0.48 to 0.85) had significantly lower odds for using refillable tanks than other adults.

Smoking status and current regular ENDS use

Table 3 shows the results of weighted univariate logistic regression models using smoking status (current or former smoker vs. never as the reference) as the predictor and current regular ENDS use by device type as the outcome in each age group. In the youth subsample, being a current versus never smoker was associated with greater odds of current regular use of cigalikes (OR=2.79, 95% CI 1.63 to 4.78), disposables (OR=2.33, 95% CI 1.40 to 3.90), refillable tanks (OR=2.27, 95% CI 1.37 to 3.76), closed pods (OR=2.62, 95% CI 1.59 to 4.30), drippers (OR=6.32, 95% CI 3.15 to 12.68), and multiple ENDS device types (OR=2.28, 95% CI 1.41 to 3.69). Being a former smoker was not significantly associated with ENDS use among youth. Within the young adult subsample, being a current versus never smoker was associated with greater odds of being a current regular user of refillable tanks (OR=1.80, 95% CI 1.01 to 3.21), refillable pods (OR=2.63, 95% CI 1.22 to 5.67), closed pods (OR=2.20, 95% CI 1.20 to 4.03), drippers (OR=4.89, 95% CI 1.69 to 14.15) and multiple ENDS device types (OR=2.48, 95% CI 1.40 to 4.40). Conversely, for young adults, being a former (vs never) smoker was associated with lower odds of using cigalikes. For the other adult subsample, being a current versus never smoker was not significantly associated with being a current regular user of any ENDS device types, although being a former smoker (vs. never) was associated with lower odds of current regular disposable use.

DISCUSSION

This survey measured current regular use of ENDS device types and smoking status with a national sample of youth, young adults and other adults. Results showed different patterns for ENDS device type and smoking status among age groups. These findings are informative for the FDA as they continue to monitor and enforce policy on ENDS allowed on the US market, especially ENDS that facilitate the public health goals of reducing tobacco use.

Youth and young adults had higher odds of reporting current regular use of disposables, closed pods, drippers and multiple ENDS device types. Changes to FDA enforcement priorities in 2020 aimed at reducing youth and young adult use of closed pod ENDS led to significant switching to disposables.[33–36] For instance, retail data showed that from 2020 to 2022, sales of disposables doubled in the USA, including sales for disposables with 'youth appealing' flavours.[37] In our sample, disposables were the most commonly used ENDS device type for young adults and the second most among youth (figure 1). Moreover, youth and young adults had greater odds of being current regular disposable users than other adults (table 2).

Table 2 Weighted univariate logistic regression of each ENDS device type use on age groups with 30+ as the reference group

	Cigalike*	Disposable	Refillable tank	Refillable pod	Closed pod	Dripper	Multiple ENDS types†
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age group‡							
13–17	**2.71 (1.94 to 3.78)**	**3.44 (2.55 to 4.64)**	**0.61 (0.46 to 0.79)**	0.93 (0.67 to 1.27)	**2.57 (1.94 to 3.40)**	**2.86 (1.83 to 4.47)**	**2.21 (1.69 to 2.89)**
18–29	1.17 (0.80 to 1.70)	**3.67 (2.67 to 5.05)**	**0.64 (0.48 to 0.85)**	0.95 (0.68 to 1.33)	**1.58 (1.17 to 2.14)**	**1.94 (1.20 to 3.13)**	**1.68 (1.26 to 2.25)**
30+	Referent	Referent	Referent	Referent	Referent	Referent	Referent
p	p<0.001	p<0.001	p<0.001	p=0.887	p<0.001	p<0.001	p<0.001

Bold indicates p<0.05.
*Current regular use of each ENDS type was scored as follows: 0 = 'No, have not used device fairly regularly (at least several times a week or more) in the past 30 days' or 1 = 'Yes, used device fairly regularly (at least several times a week or more) in the past 30 days'. 'Refused to answer' responses were treated as missing in analyses.
†Current regular use of multiple ENDS types was scored as follows: 0=Do not currently use devices listed in survey or only use a single listed ENDS type, or 1=Yes, currently use two or more of the listed ENDS types. Participants could identify multiple ENDS types so that participants who indicated they used two ENDS types (e.g., cigalikes and disposables) would be counted as a current regular user of cigalikes, disposables and multiple ENDS types.
‡Since participants could identify current regular use of multiple ENDS types, current regular use of each END type was assessed in separate univariate logistic regression models.
ENDS, electronic nicotine delivery systems.

Closed pods were the most used ENDS device type for youth and the second most used for young adults. Both groups had higher odds of current regular use of closed pods than other adults. This suggests that the FDA enforcement policy to steer youth away from closed pods may yet to have had an effect in 2021 or may need to be strengthened or expanded. Many closed pods use *nicotine salts*, a chemically engineered e-liquid designed to reduce the bitter taste of nicotine, allowing manufacturers to increase nicotine concertation without irritating users when they inhale, thus heightening nicotine addiction risk.[38–44] Nicotine salts initially became prevalent among youth via closed pods, prompting FDA actions on flavoured closed pods other than tobacco or menthol to reduce youth use.[45 46] In addition, menthol closed pods remained on the market, and menthol was a popular flavour among youth.[36] The continued high use of these products by youth suggests that FDA should take further steps to reduce youth use and consider the high youth use of closed pods when making marketing authorisation decisions.

Youth and young adults were more likely to use drippers than other adults. The risk of drippers and their appeal among youth[20 21]—including as is described in this report—suggests that they should be scrutinised as the FDA seeks to curb youth vaping and protect public health. For instance, mandating that ENDS devices are closed so that coils are not open and exposed would be one way to possibly limit dripping. It is unlikely that drippers are used for quitting smoking, given reports identifying dripping as a social activity for youth centred around doing 'vape tricks' and blowing big vapour clouds.[20] Moreover, for those youth (54.3%) and young adults (31.4%) classified as never smokers, any ENDS device types were likely starter products for initiating tobacco.

Refillable tanks were the only ENDS device type with lower odds of current regular use for youth and young adults (vs. other adults). Past research has found that people trying to quit smoking favoured refillable tanks over other ENDS. According to Population Assessment of Tobacco and Health Study data from 2015 to 2016, among adult dual users of ENDS and cigarettes, those who used closed pods, refillable tanks, or mods (i.e., modifiable ENDS device type) had higher odds of smoking quit attempts than those using disposables.[47] Data from the 2016 ITC four-country survey (Australia, Canada, England and USA) showed that adults who smoked and used refillable tanks were more likely to endorse 'helps quit smoking' as a reason for vaping than those who used disposables.[48] ITC data from 2020 found that among adults who co-used ENDS and cigarettes, those using refillable tanks and closed pods were more likely to cite "quit smoking" as a reason for vaping than users of disposables.[34] Refillable tanks were the only ENDS device type that other adults had higher odds of current regular use versus both youth and young adults, and, notably, most other adults (56.7%) were former smokers. Other adult former smokers were twice as likely to be using

Table 3 Weighted univariate logistic regression of each ENDS device type use on smoking status (reference group: never) for each age group

	Cigalike	Disposable	Refillable tank	Refillable pod	Closed pod	Dripper	Multiple ENDS types†
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Youth (13–17 years old)							
Smoking status							
Current	**2.79 (1.63 to 4.78)**	**2.33 (1.40 to 3.90)**	**2.27 (1.37 to 3.76)**	1.52 (0.87 to 2.66)	**2.62 (1.59 to 4.30)**	**6.32 (3.15 to 12.68)**	**2.28 (1.41 to 3.69)**
Former	0.64 (0.11 to 3.64)	0.48 (0.09 to 2.65)	2.87 (0.63 to 12.81)	0.28 (0.03 to 2.45)	1.59 (0.36 to 7.15)	.*	1.68 (0.38 to 7.51)
Never	Referent	Referent	Referent	Referent	Referent	Referent	Referent
p	p<0.001	p=0.003	p=0.005	p=0.138	p<0.001	p<0.001	p=0.004
Young adults (18–29 years old)							
Smoking status							
Current	1.48 (0.75 to 2.93)	1.14 (0.64 to 2.02)	**1.80 (1.01 to 3.21)**	**2.63 (1.22 to 5.67)**	**2.20 (1.20 to 4.03)**	**4.89 (1.69 to 14.15)**	**2.48 (1.40 to 4.40)**
Former	**0.05 (0.02 to 0.17)**	0.96 (0.45 to 2.04)	1.91 (0.89 to 4.12)	1.69 (0.64 to 4.48)	1.14 (0.52 to 2.50)	1.77 (0.40 to 7.78)	1.03 (0.48 to 2.24)
Never	Referent	Referent	Referent	Referent	Referent	Referent	Referent
p	p<0.001	p=0.849	p=0.102	p=0.040	p=0.018	p=0.006	p=0.002
Other adults (30+ year olds)							
Smoking status							
Current	1.83 (0.47 to 7.13)	0.63 (0.24 to 1.64)	0.95 (0.39 to 2.32)	0.70 (0.24 to 2.07)	0.83 (0.30 to 2.28)	1.15 (0.23 to 5.77)	0.67 (0.27 to 1.64)
Former	0.54 (0.13 to 2.18)	**0.26 (0.10 to 0.70)**	1.89 (0.79 to 4.53)	0.97 (0.34 to 2.80)	0.60 (0.22 to 1.64)	0.71 (0.14 to 3.61)	0.52 (0.21 to 1.27)
Never	Referent	Referent	Referent	Referent	Referent	Referent	
p	p<0.001	p<0.001	p=0.002	p=0.369	p=0.267	p=0.490	p=0.241

Bold indicates p<0.05 for current regular use by ENDS type on current or former smoking status versus the referent of never smoked. All results are ORs except where indicated.
*Due to the small number of youth who were both former smokers and dripper users, we could not reliably calculate OR for association between former smoking status and current dripper use.
†Since participants could identify multiple ENDS types, current regular use of each END type was assessed in weighted univariate logistic regression models.
ENDS, electronic nicotine delivery systems.

refillable tanks as other adult current smokers, although this difference was not statistically significant. Finally, data from 2018 to 2019 TUS-CPS surveyed adults in the USA to evaluate how ENDS device types associated with smoking cessation. Refillable tanks were the most used ENDS devices for people who quit smoking by switching to ENDS in the past year, and dual users who tried to quit in the past year but not for dual users who did not make a quit attempt.[49] These results may suggest that refillable tanks are products that are more likely to be associated with having quit smoking than with dual use.

Limitations

Participants were online survey panelists. Panel conditioning, whereby participants' beliefs, attitudes and behaviours could be affected by prior survey studies they have completed, could lower the sample's representativeness. This concern is partially mitigated by incorporating an opt-in panel and an internal examination by Ipsos that found limited evidence for panel conditioning. Although several quality assurance checks were used in the design, and open-ended responses to questions were manually coded for accuracy, it is possible that some participants were not answering carefully or truthfully. The consent and assent documents for the youth participants mentioned that the survey would ask about ENDS use. This could result in selection bias related to parents willing to let their children answer about ENDS use. Furthermore, the survey was collected in 2021 and may not reflect the ongoing evolution of ENDS device types, recent FDA marketing decisions and current regulation

of ENDS. We defined being a 'current' smoker based on having smoked 100 cigarettes in a lifetime, which may be a more accessible benchmark for adults than youth, which is a consideration for our results. We measured fairly regular use of any ENDS device type rather than trying to establish the most frequent or preferred types. Other studies have looked at preferred device type.[50] We ran multiple models, which might increase the chance of type 1 error for some results, although we provided p values for age group and smoking status to calculate Bonferroni corrections. Some of the analyses may be more powered than others (e.g., Drippers) based on existing sample sizes. Finally, the analyses did not account for flavours used; all ENDS device types assessed could come in various flavours, even after announcement of FDA enforcement priorities on certain flavours in 2019. As states and localities introduce flavour restrictions, future studies should examine how these regulations influence shifts in device type use.

CONCLUSION

US ENDS users of different ages use different ENDS device types, with youth being more likely to use cigalikes, disposables, drippers and multiple ENDS device types compared with other adults. Refillable tanks were the only ENDS device type other adults used more than youth and young adults. Among youth, current (vs never) smokers had greater odds of current regular use for cigalikes, disposables, refillable tanks, closed pods and drippers. Similarly, 18–29 years old current (vs. never) smokers had higher odds of reporting current regular use of refillable tanks, refillable pods, closed pods and drippers. Both age and smoking status were associated with current regular use of ENDS, especially for youth and young adults. ENDS device types that are used commonly by youth and less so by other adults should be considered for stricter regulation.

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