

Trends in vaping in the US population between 2013 and 2023: changes in vaping days among youth versus adults

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ABSTRACT

Objective To examine population level patterns of e-cigarette use between 2013–14 and 2022–23 by analysing trends in the total number of vaping days by youth versus adults. The vaping days measure offers added value by combining how many people are vaping with how frequently they vape.

Methods The study used repeated cross sectional data from youth (aged 12–17 years) and adults (aged ≥18 years) from Wave 1 (2013–14) to Wave 7 (2022–23) of the Population Assessment of Tobacco and Health (PATH) study, a nationally representative longitudinal study conducted in the US. Population level vaping days were calculated as the total number of days e-cigarettes were used in the population in the past 30 days at each wave. Vaping days was analysed over time by age group.

Results Between 2013–14 and 2022–23, increases were observed in population vaping days (+183%), past 30 day vaping (+45%) and daily vaping (+230%). Vaping days among those under the minimum legal age of 21 years and who vaped in the past 30 days more than quadrupled (+337%) over the study period and accounted for 16% of all vaping days in 2022–23. Adult vaping days continued to increase since the pandemic due to increases in vaping frequency among adults and population growth.

Conclusion Vaping consumption, measured as either the prevalence of daily vaping or total vaping, increased since 2013–14 in the US. This suggests that since 2013–14, not only are more individuals in the US vaping, but those who vape are doing so more frequently.

BACKGROUND

The extent of harm reduction from e-cigarettes depends on who is using e-cigarettes and for what reasons.¹ It is well established that e-cigarettes can serve as an effective form of smoking cessation for adults who smoke,^{2–4} but e-cigarettes also appeal to young people, most of whom have little or no smoking history.⁵ Concerns have also been raised about the increased risks of dual use, where individuals vape and smoke without fully transitioning away from cigarettes, as well as the re-entry of individuals with a low risk of smoking relapse into the nicotine market.

Monitoring of e-cigarette use is a public health priority in the USA,⁶ but few data sources capture both adult and youth vaping trends. The National Youth Tobacco Survey (NYTS) has provided the most consistent estimates of vaping among young people in the USA and depicts notable changes over

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ E-cigarette use is prevalent in the US, with substantial use among adults and young people.

WHAT THIS STUDY ADDS

⇒ Evidence on trends in overall population level e-cigarette consumption in the US is limited, particularly with respect to comparisons between youth and adults.
⇒ This study addressed this gap by using a novel vaping days measure that captured not only how many people use e-cigarettes, but also how frequently they vape.

HOW THIS STUDY MIGHT AFFECT RESEARCH PRACTICE OR POLICY

⇒ Incorporating measures of vaping frequency into e-cigarette surveillance systems may improve monitoring of population level consumption trends and provide an additional assessment of the public health impact of e-cigarettes.

time. Current vaping (past-30-day use) increased among middle and high school students between 2013 (3.1%) and 2019 (20.2%), with particularly large increases from 2017 to 2019, and then decreased in 2020 (13.3%), followed by further declines between 2021 (7.5%) and 2024 (5.9%).^{7,8} Dynamic trends of adult e-cigarette use have also been observed in the USA. Data from the National Health Interview Survey (NHIS) indicated that current e-cigarette use among adults aged ≥18 years increased between 2014 (3.7%) and 2019 (4.5%), declined in 2020 (3.7%), and then increased from 2020 to 2023 (6.5%).^{9,10} Young adults consistently demonstrated the highest prevalence of adult e-cigarette use. In 2023, 15.5% of adults aged 21–24 years reported current use.⁹

The focus on either youth or adult populations has given few integrated estimates of vaping at the population level. In addition, the most commonly reported metric used to assess e-cigarette use is point prevalence of vaping in the past 30 days. Past 30 day vaping prevalence provides a useful metric to track changes over time, but also a general one that fails to reflect notable differences in the frequency and intensity of vaping among those who vaped in the past 30 days.¹¹ Moreover, several studies suggested that the frequency of vaping has



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increased over time, in parallel with the emergence of e-liquids that use nicotine salt formulations, first introduced by JUUL.^{11–13} In addition, whereas youth studies have suggested increases in frequent vaping and indicators of dependence since 2017,^{11 13 14} there are few comparative data among adults to examine similar trends.

Sales data provide an alternative method for measuring population level e-cigarette consumption, but existing sales data in the US (eg, Nielsen retail sales) only capture conventional brick and mortar stores and exclude online stores, vape shops and illicit sources, which are estimated to account for approximately half of the e-cigarette market.¹⁵ In addition, online stores and vape shops offer a wide range of e-cigarette products.^{16 17} Thus, the widely used sales data from Nielsen are a poor indicator of total market size, including trends over time.

Overall, there is limited evidence on trends in overall e-cigarette consumption at the population level in the US, including comparisons between youth and adults. The current study uses data from the Population Assessment of Tobacco and Health (PATH) Study to estimate trends in the total number of vaping days over a 10-year period. Vaping days reflects the number of days that were vaped in the population within a specific period of time, which provides an alternate estimate of vaping consumption that can also be scaled to annual estimates. The PATH Study is also among the few studies that include both youth and adults, which allows direct estimates of vaping prevalence and patterns of use. The current study had two specific aims: to examine trends in the total number of vaping days at the population level between 2013–14 and 2022–23 and to estimate the proportion of vaping days accounted for by age, including those below the minimum legal age of 21 years.

METHODS

Sample

Data were from youth (aged 12–17 years) and adults (aged ≥18 years) from Waves 1 (2013–14) to 7 (2022–23) of the PATH Study (see table 1 for sample sizes). The PATH Study is an ongoing, nationally representative, longitudinal cohort study of youth (aged 12–17 years) and adults (≥18 years) in the USA, which collects information on tobacco use patterns and associated health behaviours. The PATH Study recruitment for the Wave 1 cohort used a stratified address based, area probability sampling design that oversampled adults who used tobacco, young adults (aged 18–24 years) and Black or African American adults. An in-person screener was used at Wave 1 to randomly select youth and adults from households for participation in the study. At Waves 4 and 7, probability replenishment samples of adults and youth were selected from the US civilian non-institutionalised population (CNP).

Data were from 45 971 interviews conducted at Wave 1 (32 320 adults/13 651 youth), 40 534 interviews conducted at Wave 2 (28 362 adults/12 172 youth), 39 962 interviews conducted at Wave 3 (28 148 adults/11 814 youth), 48 620 interviews conducted at Wave 4 (33 822 adults/14 798 youth), 46 407 interviews conducted at Wave 5 (34 309 adults/12 098 youth), 36 168 interviews conducted at Wave 6 (30 516 adults/5652 youth) and 41 635 interviews conducted at Wave 7 (30 801 adults/10 834 youth). The youth sample in Wave 6 was restricted to older youths (aged 14–17 years) due to the ageing of the original Wave 4 (2016–18) cohort.

Further details on the PATH study design and methods for the Wave 1 cohort are published elsewhere.^{18–20} The analyses presented here used the restricted use files.²¹ Details on interview

Table 1 Characteristics of the Population Assessment of Tobacco and Health (PATH) study sample at each wave*

	Wave 1 (2013–14)	Wave 2 (2014–15)	Wave 3 (2015–16)	Wave 4 (2016–18)	Wave 5 (2018–19)	Wave 6† (2021)	Wave 7 (2022–23)
Youth (aged 12–17 years)							
No. of youth	13 650	12 143	11 781	14 793	11 928	5566	10 650
Sex							
Male	51.3 (6993)	51.3 (6225)	51.4 (6104)	51.2 (7697)	51.1 (6233)	51.3 (2931)	51.2 (5578)
Female	48.7 (6657)	48.7 (5918)	48.6 (5677)	48.8 (7096)	48.9 (5695)	48.7 (2635)	48.8 (5072)
Past 30 day vaping ('yes')	3.1 (418)	3.6 (415)	4.1 (454)	4.3 (598)	8.6 (1083)	5.9 (325)	5.4 (637)
Daily/ near daily vaping (≥20 days)	0.4 (48)	0.5 (56)	0.7 (71)	0.7 (91)	2.3 (283)	1.9 (107)	1.7 (203)
Adults (aged ≥18 years)							
No. of adults	32 320	28 362	28 148	33 644	32 687	29 516	29 780
Sex							
Male	48.1 (16321)	48.0 (14022)	47.9 (13786)	48.1 (16517)	48.1 (15864)	48.0 (14027)	48.5 (14085)
Female	51.9 (15993)	52.0 (14310)	52.1 (14333)	51.9 (17125)	51.9 (16780)	52.0 (15451)	51.5 (15695)
Age group (years)							
18–20	5.4 (3762)	5.3 (3937)	5.3 (4623)	5.4 (6218)	5.1 (6047)	5.0 (5121)	5.0 (4721)
21–24	7.7 (5360)	7.4 (4244)	7.1 (3834)	7.1 (5001)	6.9 (5309)	6.7 (5512)	6.6 (5589)
25–34	17.7 (6337)	17.5 (5674)	17.5 (5824)	17.9 (6874)	17.2 (6928)	16.8 (6443)	17.3 (6948)
35–44	16.5 (4931)	16.5 (4200)	16.1 (3971)	16.2 (4460)	16.2 (4141)	16.4 (3540)	16.9 (3548)
45–54	17.9 (4847)	17.2 (4030)	17.2 (3804)	16.7 (4142)	15.8 (3543)	15.3 (2846)	15.7 (2848)
55–64	16.6 (3973)	17.0 (3507)	17.2 (3389)	17.3 (3842)	17.3 (3587)	17.1 (3099)	16.8 (2984)
≥65	18.2 (3110)	19.1 (2770)	19.6 (2703)	19.6 (3107)	21.4 (3132)	22.7 (2955)	21.6 (3142)
Past 30 day vaping ('yes')	6.7 (4430)	6.3 (3378)	7.0 (3792)	6.2 (4050)	8.9 (5722)	7.3 (3821)	8.9 (4741)
Daily/near daily vaping (≥20 days)	1.5 (905)	2.0 (987)	2.0 (1003)	2.1 (1220)	3.3 (1987)	3.6 (1828)	4.4 (2261)

Data are weighted % (unweighted numbers).

*All PATH study participants surveyed at each wave were included, regardless of vaping status.

†Older minimum age of youth (~14–17 years) was sampled in this wave.

procedures, questionnaires, sampling, weighting, response rates and accessing the data are described in the PATH Study Restricted Use Files User Guide (<https://www.icpsr.umich.edu/sites/nahdap/view/collections/606>). The PATH study was conducted by Westat and approved by the Westat Institutional Review Board. The study reported here was approved by the Roswell Park institutional review board (BDR070116). All respondents aged ≥ 18 years provided informed consent, and youth respondents (aged 12–17 years) provided assent; their parent or legal guardian provided consent. Participants in the PATH Study youth survey who aged up (i.e., turned age 18 years) were invited to participate in the adult survey in a later wave.

Measures

Sociodemographic measures

Sociodemographic measures included sex (male/female) and age (youth: aged 14–17 years at Wave 6 and aged 12–17 years at all other waves; adults: aged 18–20, 21–24, 25–34, 35–44, 45–54, 55–64 and ≥ 65 years).

Vaping status

At each wave, respondents were asked about their use of e-cigarettes. At Wave 1, e-cigarettes were described as ‘e-cigarettes that look like regular cigarettes but are battery powered and produce vapour instead of smoke’. At Waves 2–7, electronic nicotine delivery systems were described as “electronic nicotine products such as e-cigarettes, e-cigars, e-pipes, e-hookahs, and personal vaporizers, as well as vape pens and hookah pens that are battery powered, use nicotine fluid rather than tobacco leaves and produce vapour instead of smoke”. Past 30 day vaping was assessed with the question, “In the past 30 days, have you used an electronic nicotine product, even one or two times?” Response options were ‘yes’, ‘no’, ‘don’t know’ and ‘refused’. Daily/near daily vaping was assessed with the question, “How many of the past 30 days did you use an electronic nicotine product?” Use on ≥ 20 days was classified as daily/near daily vaping.^{22–24} For simplicity, this category is referred to as daily vaping throughout the manuscript.

Vaping days

Population-level vaping days were calculated as the total number of days e-cigarettes were used in the population in the past 30 days among those who vaped in the past 30 days at each wave.

Analysis

Full sample and replicate weights were created to adjust for the complex sample design (eg, oversampling of specified groups) and non-response. Weighted estimates represent the resident population of the US aged ≥ 12 years at the time the specific data were collected, and who were in the civilian non-institutionalised population at the preceding replenishment wave. This analysis used cross sectional weights at W1, W4 and W7, and used single wave weights for the Wave 1 cohort (W2–W3) or the Wave 4 cohort (W5–W6) to obtain nationally representative estimates, and variances were estimated using the balanced repeated replication method²⁵ with Fay’s adjustment set to 0.3.²⁶ Weighted estimates of the days using e-cigarettes, prevalence of past 30 day and daily vaping, and total number of days of nicotine vaping were calculated. At each wave, participants with missing data on the vaping variables of interest were excluded from the analyses. All analyses were performed using Stata survey data procedures, V.16.0 (StataCorp LLC, College Station, Texas, USA).

RESULTS

Table 1 shows the sociodemographic characteristics of the sample, along with the prevalence of past 30 day and daily vaping for both youth and adults across survey waves. Briefly, past 30 day and daily vaping increased between wave 1 and wave 7 among youth and adults.

Vaping days

Figure 1 shows the total number of days vaped in the past 30 days (vaping days), as well as past 30 day vaping and daily vaping. Between 2013–14 and 2022–23, vaping days, past 30 day vaping and daily vaping all increased, with the greatest increases observed after 2016–18. However, different patterns were observed over time across indicators: between 2013–14 and 2022–23, past 30 day vaping increased by 45%, compared with increases of 183% for vaping days and 230% for daily vaping (see online supplemental table S1 for estimates). Recent trends also differed: after 2016–18, total vaping days and daily vaping continued to increase in 2022–23, whereas past 30 day vaping was similar.

Vaping days by age

Figure 2a shows the number of vaping days in the population in the past 30 days, by age group. Between 2013–14 and 2022–23, vaping days within all age groups increased: between 2013–14 and 2022–23, vaping days among youth, young adults (aged 18–20 years) and adults aged ≥ 21 years increased by 278%, 364% and 165%, respectively. Vaping days among those under the legal age of 21 years increased by 337% between 2013–14 and 2022–23. **Figure 2b** shows vaping days by age group, as a percentage of all vaping days. Although vaping days increased among all age groups between 2013–14 and 2022–23, different patterns were observed in terms of the proportion of vaping days vaped by each age group over this period: the percentage of overall vaping days vaped by youth increased in 2018–19 but remained similar over the rest of this period (2013–14: 3.3%; 2022–23: 4.5%), increased among those aged < 21 years (2013–14: 10.3%; 2022–23: 16.0%) and decreased among adults aged ≥ 21 years (2013–14: 89.7%; 2022–23: 84.0%; see online supplemental table S1 for estimates).

DISCUSSION

The current study provides a comprehensive assessment of population level e-cigarette consumption in the US. The findings indicated substantial increases in the prevalence of past 30 day vaping between 2013–14 and 2022–23, while the increase in total vaping days among those who vaped in the past 30 days was even more pronounced. This suggests that, since 2013–14, not only are more individuals in the US vaping, but those who vape are doing so more frequently, consistent with the increase in the prevalence of daily vaping.

The vaping days measure accounts for increases in vaping frequency among non-daily vaping individuals and increases in population size over time. Changes in the size of the US population made only modest contributions to the growth in vaping days over time. For example, whereas the US population increased by 2% between 2018 and 2023, the number of vaping days was 105% higher in 2022–23 than in 2016–18 and 26% higher than in 2018–19.^{27 28} Rather, the increasing trend of vaping days at the population level was driven by both the number of people who vaped and more frequent patterns of use among those who vaped. Among adults, the prevalence of past 30 day vaping increased over the key period from 2016–18

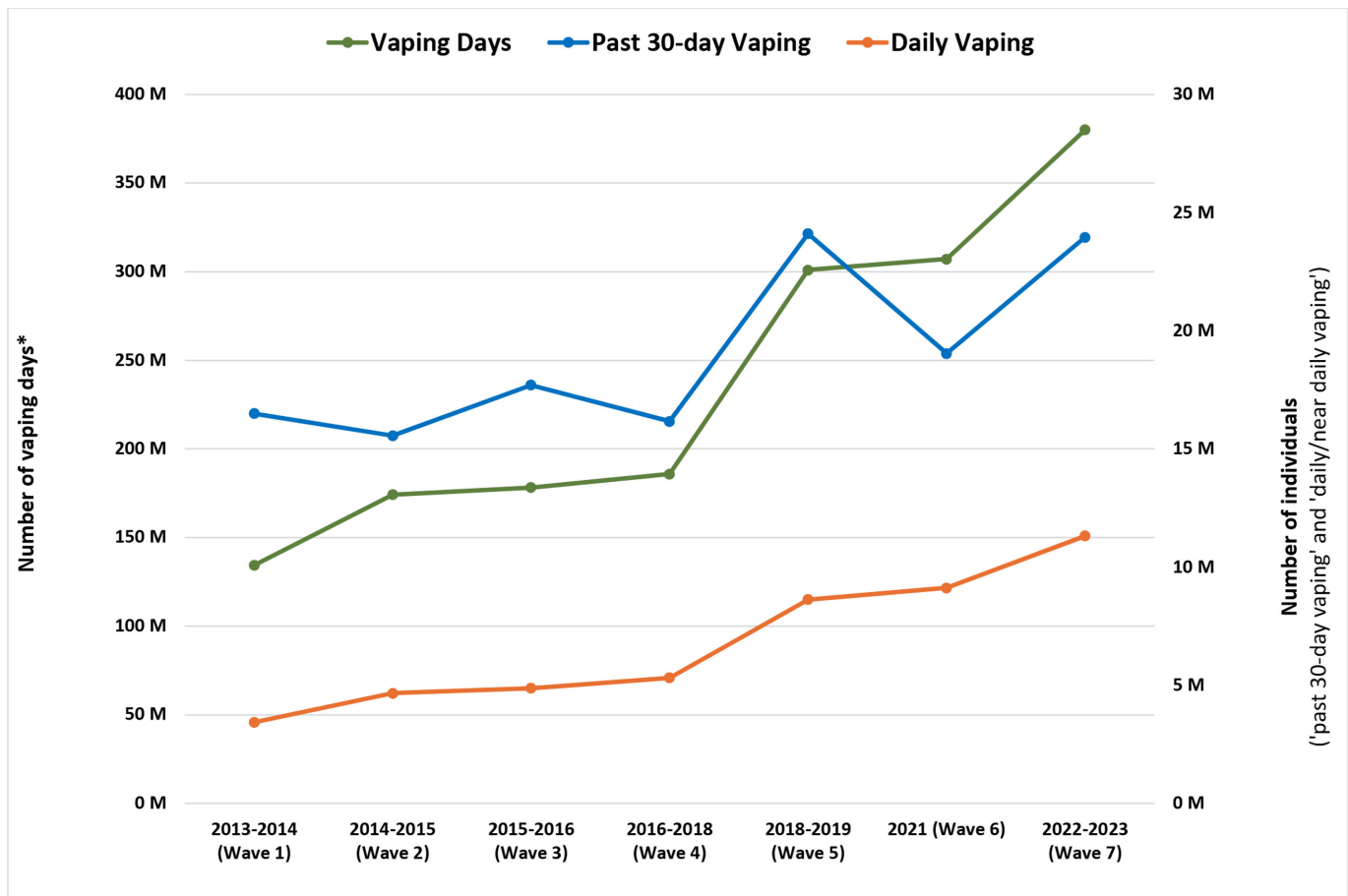


Figure 1 Population level vaping days, past 30 day vaping and daily vaping. *Total number of days vaped in the past 30 days.

to 2022–23 (from 6.2% to 8.9%, respectively), but to a lesser extent than the relative increase in frequent vaping (from 2.1% in 2016–18 to 4.4% in 2022–23). Among youth, the prevalence of past 30 day vaping in 2022–23 was moderately lower than in 2016–18 (5.4% vs 4.3%, respectively), whereas daily vaping remained higher even after declining from the peak in 2018–19 (1.7% in 2022–23 vs 0.7% in 2016–18).

Consistent with previous evidence, the most significant increases in the prevalence and frequency of vaping occurred after 2016–18, a period which corresponds with the rise of JUUL and the shift towards e-liquids containing nicotine salts.^{7 11 13 29} Nicotine salts have been associated with greater ease of inhalation and vaping frequency among youth and adults.^{30–33} Among youth, vaping days increased until a peak in 2018–19, followed by a decline since the onset of the COVID-19 pandemic, which is in line with the prevalence trends of past 30 day vaping and daily vaping in the USA.^{7 8 22} Adult vaping days have continued to increase since the pandemic, mainly due to increases in vaping frequency.

While vaping days increased across all age groups, pronounced increases between 2013–14 and 2022–23 were observed among youth and younger adults, likely influenced by industry marketing that has predominantly targeted young people^{34 35} as well as increases in the size of the youth population. Vaping days among the population under the minimum legal age of 21 years more than quadrupled (+337%) over the study period, and accounted for as much as 1 in 5 (23%) of all vaping days in 2018–19, decreasing to approximately 1 in 6 (16%) in the most recent time period in 2022–23. Interestingly, vaping days

declined to a lesser extent between 2018–19 and 2022–23 (–13%) compared with the past 30 day prevalence (–28%). Thus while fewer young people were vaping in 2022–23, those who continued to vape were likely doing so more frequently than before. The extent to which these declines may be partially offset by increased frequency of vaping among those who continue to use e-cigarettes is an important question for future research.

The findings provide important context for interpreting trends in other national surveys, including the NYTS and Monitoring the Future (MTF). While all surveys reported a sharp increase in youth vaping following the emergence of nicotine salt based products (ie, after 2017), and either a decline or levelling off since 2020, some differences emerged.^{5 7 8 36} For example, NYTS and MTF reported the highest prevalence estimates, possibly due to greater anonymity in school based surveys.^{7 8 36 37} In contrast, the PATH study, which uses a household based, longitudinal design, gives lower prevalence estimates and more moderate changes over time. These differences likely reflect variability in survey mode and sampling strategies, question wording and age profile. Triangulation of these findings across these surveys is essential in understanding population level e-cigarette use over time.

Limitations

This study had several limitations. As with all self-reported data, the PATH Study data are subject to potential reporting bias, but the PATH Study data have been previously validated and shown to have high reliability.¹⁹ A change in the mode of data collection in Wave 6 due to the COVID-19 pandemic should also

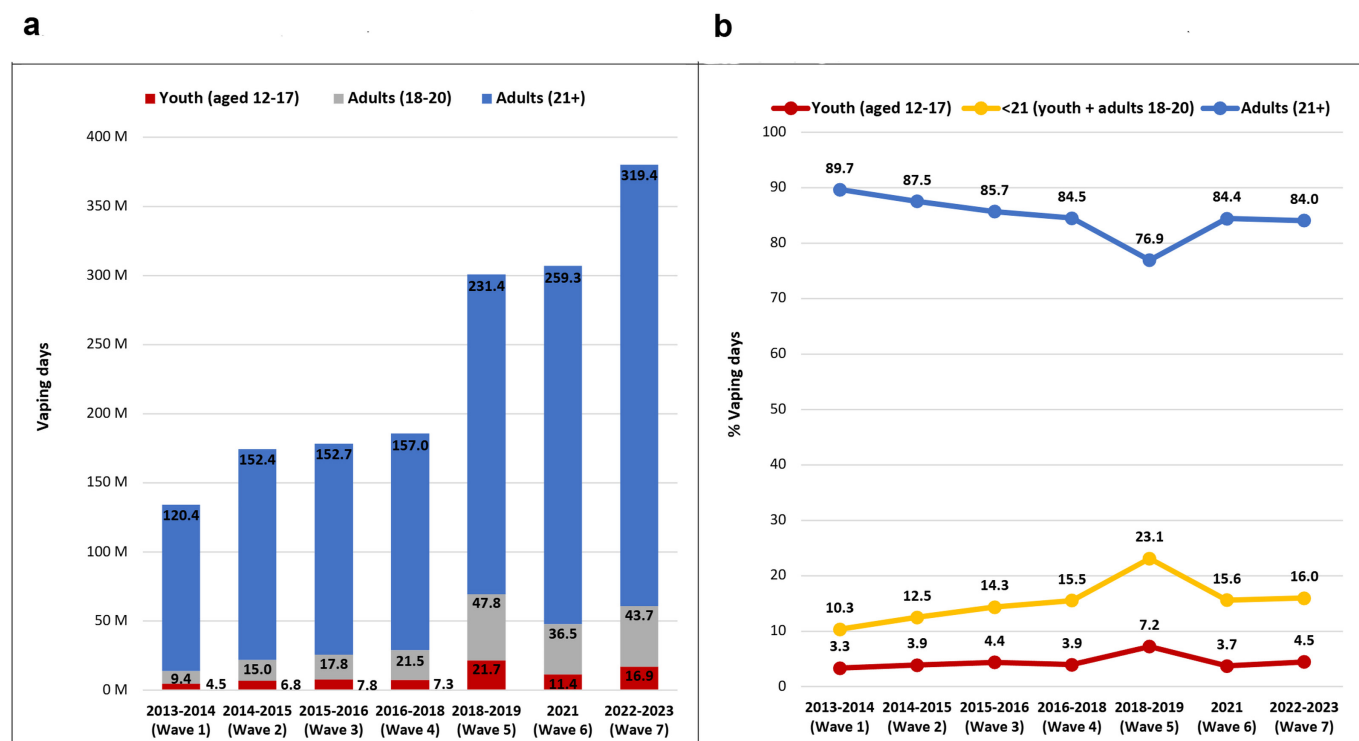


Figure 2 Percent increases in the results section that relate to (A) correspond to changes in total vaping days between 2013–14 and 2022–23. For example, 278% reflects growth in youth vaping days from 4.5 million (2013–14) to 16.9 million vaping days (2022–23). (B) Vaping days by age group, as a percentage of all vaping days.

be considered when interpreting data from that wave. In Wave 6, interviews changed to telephone interviews following the COVID-19 pandemic, but then resumed in-person (33% self-completed and 67% telephone interviews).³⁸ Different survey modes may introduce response artefacts due to varying levels of interviewer interaction. In addition, the youth sample in Wave 6 was restricted to older youths (aged 14–17 years) due to the ageing of the original Wave 4 (2016–18) cohort.

CONCLUSIONS

Our study findings indicated substantial increases in past 30 day vaping prevalence from 2013–14 to 2022–23, with even more pronounced increases in the total number of vaping days, suggesting that not only are more individuals in the US vaping since 2013–14, but those who vape are doing so more frequently, consistent with the increase in the prevalence of daily vaping. Surveillance of e-cigarette use in the US remains essential for understanding the potential risks and benefits of vaping on public health. The vaping days measure offers added value by combining how many people are vaping with how frequently they vape. This is particularly relevant given the market-wide trend towards nicotine salt e-liquids and increased frequency of use among those who vape. There are also growing concerns about dual use, where individuals engage in both smoking and vaping without fully transitioning away from cigarettes, and the potential for re-initiation of nicotine use among individuals who formerly smoked and were otherwise at low risk of relapse.

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Competing interests DH has served as a paid expert witness on behalf of public health authorities in response to litigation from the tobacco, vaping and cannabis industries.

Patient consent for publication Not applicable.

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