

# Disposable e-cigarette use and associated factors in US middle and high school students, 2021–2022

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## ABSTRACT

**INTRODUCTION** Disposable e-cigarettes are the predominant type of vaping product used by adolescents and pose a significant public health concern. Identifying factors contributing to this growing trend is essential to curbing the vaping epidemic among youths. This study aims to investigate the growing prevalence and correlates of disposable e-cigarette use among US students.

**METHODS** Data from 48437 US middle and high school students from the 2021 and 2022 National Youth Tobacco Survey (NYTS) were analyzed using logistic and ordinal regression models to evaluate disposable e-cigarette use and frequency of use (low, medium, and high) with demographic and psychosocial factors. Weighted prevalence of current e-cigarette use with 95% CIs by device types in 2021 and 2022, were calculated. Odds ratios (ORs) of correlations of disposable e-cigarette use and frequency of use with demographic and psychosocial factors were analyzed.

**RESULTS** Disposable e-cigarette use increased from 3.9% (95% CI: 3.3–4.7) in 2021 to 5.1% (95% CI: 4.2–6.1) in 2022, and was associated with being female (OR=1.57; 95% CI: 1.29–1.91 vs male), high schoolers (OR=5.14; 95% CI: 3.96–6.67 vs middle schoolers), having low harm perceptions of e-cigarettes (OR=7.75; 95% CI: 5.58–10.75 vs lot of harm), and high exposure to marketing (OR=1.57; 95% CI: 1.05–2.35 vs low exposure). Identifying as LGBTQ (OR=1.41; 95% CI: 1.00–2.00 vs straight), having low academic performance (OR=2.16; 95% CI: 1.15–4.07, D vs A grades), and having psychological distress (OR=2.01; 95% CI: 1.64–2.47, severe vs none) were also linked to increased frequency of use.

**CONCLUSIONS** This study underscores increasing disposable e-cigarette use among US students, noting existing disparities. It identifies high-risk adolescent subgroups vulnerable to disposable e-cigarette use. These findings emphasize the urgency of targeted prevention and stricter regulations on disposable e-cigarettes to combat nicotine addiction among youths.

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## INTRODUCTION

Disposable e-cigarettes have become increasingly popular among youth and have a leading role among vaping products<sup>1</sup>. Notably, these disposable devices have become the most commonly used type in the US and many European countries, contributing significantly to the rapid escalation of the vaping epidemic among adolescents<sup>2,3</sup>. Current use of disposable e-cigarettes among US high-school students soared from 0.7% in 2019 to 5.1% in 2020<sup>1</sup>, and from 0.1% to 10.7% among 18-year-olds in the UK between 2021 and 2022<sup>1,4</sup>.

Their attractive design, flavors, and ease of use have made these single-use devices especially attractive to youth, a trend intensified by targeted marketing<sup>3</sup>. The tobacco industry's targeted campaigns have historically exacerbated health disparities, with e-cigarette use now disproportionately impacting racially or sexually minoritized youth and those with physical or mental health challenges<sup>5,6</sup>.

In 2020, the Food and Drug Administration (FDA) banned flavored e-cigarette sales<sup>7</sup>. However, unregulated disposable devices have grown even more popular among adolescents since then. Despite the FDA's ban on sales to youths<sup>8</sup>, illegal use in this demographic remains a great public health concern<sup>3,9,10</sup>.

While there is a growing number of studies on e-cigarettes, a distinct gap exists in the focus on disposable e-cigarettes and the factors influencing their use. Using data from the 2021 and 2022 National Youth Tobacco Survey (NYTS), our study addresses a critical gap in existing evidence. We aim to investigate factors linked to disposable e-cigarette use and frequency of use among US students to improve understanding of the phenomenon and inform future decisions regarding relevant regulations.

## METHODS

We analyzed data from the 2021 and 2022 NYTS.

The NYTS is a nationally representative, school-based, self-administered, electronically administered survey. The analysis pooled a total of 48437 students: 21804 from middle school (grades 6–8) and 26633 from high school (grades 9–12) across 2021 and 2022 of all students who undertook the survey during this time. Current use was defined as any use in the past 30 days.

Questions on demographic, psychosocial characteristics, e-cigarette device types, and use patterns are detailed in technical reports<sup>11</sup>. Study variables were selected based on existing literature on youth e-cigarette use, and CDC further guided their categorization reports<sup>12</sup>. Multivariable regression models were constructed using a step-wise method. We included variables identified from the literature as important predictors. The final specification of the models was informed by the Akaike Information Criterion (AIC), reinforcing the robustness of our approach.

The complex survey designs were accounted for in the statistical analyses using Stata 17<sup>13</sup>. We calculated weighted prevalence estimates for using various e-cigarette types across both surveys. Weighted logistic and ordinal regression models assessed how demographic and psychosocial factors were associated with disposable e-cigarette use among the total sample and frequency of use (categorized by 1–5, 6–19, and

**Table 1. Weighted prevalence of e-cigarette use among middle and high school students by device types in the National Youth Tobacco Survey, United States, 2021 and 2022**

	2021 NYTS (N=20278)				2022 NYTS (N=28159)			
	Disposable	Refillable pods/cartridges	Tanks/mod systems	Don't know	Disposable	Refillable pods/cartridges	Tanks/mod systems	Don't know
Prevalence in NYTS sample, n (%; 95% CI)	744 (3.9; 3.3–4.7)	422 (2.1; 1.7–2.6)	120 (0.7; 0.5–0.9)	118 (0.6; 0.5–0.8)	1443 (5.1; 4.2–6.1)	654 (2.3; 1.7–3.2)	206 (0.6; 0.5–0.8)	356 (1.2; 0.9–1.5)
	2021 Current e-cig use (N=1404)				2022 Current e-cig use (N=2659)			
	Disposable	Refillable pods/cartridges	Tanks/mod systems	Don't know	Disposable	Refillable pods/cartridges	Tanks/mod systems	Don't know
Prevalence in current e-cig users, %; 95% CI	53.7 (48.8–58.6)	28.7 (25.0–32.6)	9.0 (6.8–11.8)	8.6 (6.7–11.0)	55.3 (49.4–61.0)	25.2 (19.7–31.5)	6.7 (5.3–8.4)	12.8 (10.2–16.1)

The first row shows weighted prevalence for the total population (N=20278), and the second row shows prevalence within the current e-cigarette user population (N=1404) in each survey year. Current use defined as use of any e-cigarettes in the past 30 days. e-cig: e-cigarette.

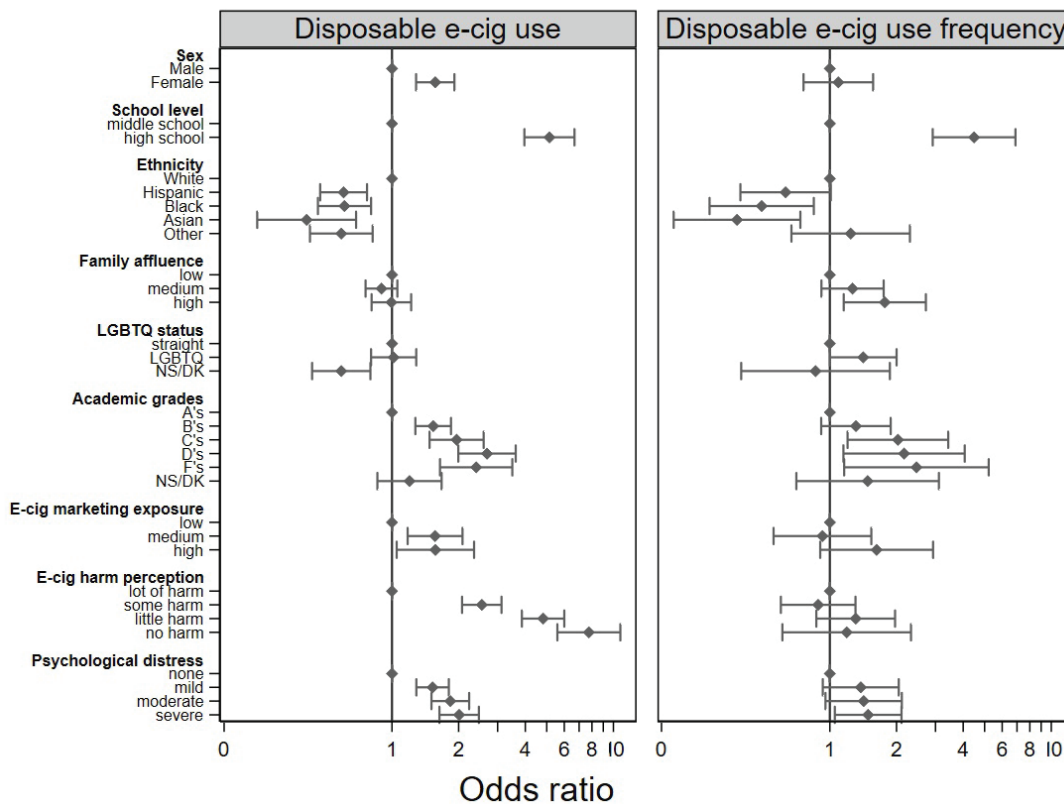
20–30 days usage in the last 30 days)<sup>12</sup> among current disposable e-cigarette users, respectively, adjusting for survey waves. The proportional odds assumption in the ordinal logistic models was assessed using appropriate statistical tests to ensure model validity. We set the level of statistical significance at 5%, and all tests were two-tailed. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs).

## RESULTS

The prevalence of current disposable e-cigarettes increased from 3.9% in 2021 to 5.1% in 2022 among US adolescents (Table 1); they were the most commonly used type in both years (accounting for more than half the students reporting e-cigarette use in both years).

Analyses showed that female students had higher

**Figure 1. Estimation of association between individual-level factors and disposable e-cigarette use among middle and high school students (A) and frequency of use among current disposable e-cigarette users (B) in the National Youth Tobacco Survey, United States, 2021 and 2022**



Association estimates (odds ratios) were obtained from binary logistic regression models in model A and from ordinal logistic regression models in model B (weighted data assessed using complex survey designs), with all listed variables in the models and controlled for NYTS survey years. The x-axis is displayed on a logarithmic scale: LGBTQ status: lesbian, gay, bisexual, and transgender. e-cig: e-cigarette. NS/DK: 'not sure or don't know'. **Frequency of e-cigarette use:** Respondents who reported current use were asked: 'During the past 30 days, on how many days did you use e-cigarettes?'. Response options ranged between 0 and 30 days. Response options were categorized as 1–5 days (low frequency), 6–19 days (medium frequency), and 20–30 days (high frequency). **Family affluence:** a composite scale of family affluence made up of four questions. Numeric values were assigned to each response and summed across responses: 1) 'Does your family own a vehicle (such as a car, van, or truck)?' [no = 0; yes, one = 1; yes, two or more = 2]; 2) 'Do you have your own bedroom?' [no = 0; yes = 1]; 3) 'How many computers (including laptops and tablets, not including game consoles and smartphones) does your family own?' [none = 0; one = 1; two = 2; more than two = 3]; and 4) 'During the past 12 months, how many times did you travel on vacation with your family?' [not at all = 0; once = 1; twice = 2; more than twice = 3]. Summed responses (range: 0–9) were categorized into approximate tertiles based on the distribution of scores of the answers: low (0–5), medium (6–7), and high (8–9). **E-cig marketing exposure:** a composite scale of exposure to e-cigarette marketing. Exposure to e-cigarette product marketing was assessed for each of four marketing sources (retail stores, Internet, television, streaming sources, or movies, and newspapers or magazines) and any source combined, and then a composite measure of exposure to any tobacco product marketing was calculated. For each of the four marketing sources, exposure was assessed by the questions: 'When you go to retail stores/use the internet/watch the television, streaming sources, or movies/read newspapers or magazines, how often do you see ads or promotions for e-cigarettes?'. Response options were numerically coded: 1='I do not use the above resources', 2='never', 3='rarely', 4='sometimes', 5='most of the time', and 6='always'. A composite measure of exposure to any e-cigarette marketing was categorized into approximate tertiles based on the distribution of scores of the answers: low (0–8), medium (9–16), and high (17–24). **E-cig harm perception:** Assessed by the questions: 'How much do you think people harm themselves when they use e-cigarettes some days but not every day?'. Response options included: 'no harm', 'little harm', 'some harm', and 'a lot of harm'. **Psychological distress:** a composite scale of four questions was used to assess psychological distress: 'During the past two weeks, how often have you been bothered by any of the following problems?': 1) 'little interest or pleasure in doing things'; 2) 'feeling down, depressed, or hopeless'; 3) 'feeling nervous, anxious, or on edge'; and 4) 'not being able to stop or control worrying'. For each item, response options were numerically coded (0='not at all', 1='several days'; 2='more than half of the days'; and 3='nearly every day'; summed (range: 0–12) and categorized as none (0–2), mild (3–5), moderate (6–8), or severe (9–12).

odds (OR=1.57; 95% CI: 1.29–1.91) of using disposable e-cigarettes than males (Figure 1). High schoolers were more likely (OR=5.14; 95% CI: 3.96–6.67) and more frequent users (OR=4.48; 95% CI: 2.91–6.89) than middle schoolers. Non-White ethnicities had lower likelihood and frequency of use than White students (OR<0.61 and OR<0.63, respectively). Affluent students were more likely to use them more frequently than their non-affluent peers (OR=1.77; 95% CI: 1.16–2.71). LGBTQ students had a higher frequency of use than their straight peers (OR=1.41; 95% CI: 1.00–2.00).

Students reporting lower grades had higher odds of using, and more frequent, disposable e-cigarettes than those who reported A grades (OR=2.69; 95% CI: 1.99–3.62 and OR=2.16; 95% CI: 1.15–4.07, respectively, for students reporting a D compared to an A grade). Increased exposure to e-cigarette marketing correlated with increased use (OR=1.57; 95% CI: 1.05–2.35 for students reporting high in comparison to low marketing exposure). Moreover, students perceiving e-cigarettes as having no harm were much more likely to use them (OR=7.75; 95% CI: 5.58–10.75) than those who acknowledged their risks. Additionally, students experiencing severe psychological distress were more likely to use disposable e-cigarettes than their less distressed peers (OR=2.01; 95% CI: 1.64–2.47).

## DISCUSSION

Our study underscores the high popularity of e-cigarettes among adolescents in the US and the disparities among youth e-cigarette use. We found that disposable e-cigarette use was associated with being female, in high school, and White. We also found increased disposable e-cigarette use among LGBT students, those reporting lower academic grades, and students with mental health concerns.

These highlight the disproportional impact of disposable e-cigarettes on the vulnerable subgroups of the youth population, especially sexual and gender minority adolescents and those experiencing mental health and academic stresses. This aligns with existing evidence on tobacco use and health inequalities<sup>14</sup>, suggesting that tobacco and nicotine products are more prevalent in disadvantaged groups who also bear greater physical and mental health burdens.

Considering the popularity of disposable e-cigarettes, our findings are especially alarming and raise concerns regarding widening health and social inequalities, especially since youth exposure to nicotine and tobacco products is associated with the development of mental health disorders and respiratory issues<sup>5</sup>.

Our study also found that exposure to e-cigarette marketing and low perceptions of harm were linked to a higher likelihood of using disposable e-cigarettes. This confirms the significant impact of marketing and misconceptions of e-cigarette risks. The industry has been aggressively targeting adolescents through social media campaigns, promotional material, packaging, and product design. This strategy is particularly visible in disposable e-cigarettes, which may partly explain their commercial success. Past research has shown a positive association between increased advertising exposure and higher risks of e-cigarette use<sup>15</sup>, as well as how adolescents' misconceptions about e-cigarettes' health risks contribute to their widespread use<sup>16</sup>. Disposable e-cigarettes are not an exception, and their use continues to be driven by such factors.

## Strengths and limitations

We analyzed nationally representative data from a big sample of US adolescents and were able to explore a range of sociodemographic and psychosocial characteristics. However, the cross-sectional design prevents causal inferences. We relied on self-reported data for both ever use and frequency of use, which may be subject to recall bias. Additionally, there may be residual confounding despite adjustments for various factors. Lastly, the findings may have limited generalisability to youths in other countries with different sociodemographic and regulatory contexts. Further research could shed light on the patterns of use, preferred flavors, and sources of disposable e-cigarettes among young users.

## CONCLUSIONS

Our findings highlight not only the alarmingly high prevalence of disposable e-cigarettes in the US and driving a resurgence of e-cigarette use but also the existing disparities and, hence, the urgent need for targeted interventions for minority adolescents at higher risk of use. As the vaping landscape continues

to evolve, stronger regulations on sales and marketing around e-cigarette products, particularly disposable devices, could focus on prevention among at-risk groups and educational campaigns with mental health support to mitigate the harmful impact of disposable e-cigarettes on youth.

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#### CONFLICTS OF INTEREST

The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none was reported.

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#### ETHICAL APPROVAL AND INFORMED CONSENT

Ethical approval and informed consent were not required for this study.

#### DATA AVAILABILITY

The data supporting this research are available from the authors on reasonable request.

#### AUTHORS' CONTRIBUTIONS

DTHC: conceived the study idea and performed the formal analysis. DTHC and FTF: contributed to the methodology. DTHC and CG: wrote the first draft of the manuscript, and contributed to revising and developing the final manuscript. All authors: reviewed the manuscript and provided comments, and were involved in the interpretation of data and revision for critical intellectual input. All authors read and approved the final version of the manuscript.

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