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Nicotine Vaping and Co-Occurring Substance Use among Adolescents in the United States from 2017–2019

Noah T. Kreski, MPH [Data Analyst],
Columbia University, Mailman School of Public Health, Department of Epidemiology, 722 W 168th St, R733, New York, NY, 10032

Hadley Ankrum, BA [Graduate Student],
Columbia University, Mailman School of Public Health, Department of Epidemiology

Magdalena Cerdá, DrPH [Associate Professor],
New York University School of Medicine, Department of Population Health, 180 Madison Avenue 4-16, New York, NY, 10016

Qixuan Chen, PhD [Associate Professor],
Columbia University, Mailman School of Public Health, Department of Biostatistics, 722 West 168th Street, R644, New York NY 10032

Deborah Hasin, PhD [Professor],
Columbia University, Mailman School of Public Health, Department of Epidemiology/New York State Psychiatric Institute, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, Department of Psychiatry, 722 W. 168th Street, Room 228F, New York New York 10032

Silvia S. Martins, MD, PhD [Associate Professor],
Columbia University, Mailman School of Public Health, Department of Epidemiology, 722 West 168th Street 5th Floor Room 509, New York NY United States 10032

Mark Olfson, MD, MPH [Professor],
Columbia University, Mailman School of Public Health, Department of Epidemiology/New York State Psychiatric Institute, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, Department of Psychiatry, 1051 Riverside Dr, New York, NY 10032 Box 24

Katherine M. Keyes, PhD [Associate Professor]
Columbia University, Mailman School of Public Health, Department of Epidemiology, 722 West 168th Street #724, New York NY USA 10032

Abstract

Background: The use of electronic cigarettes (or “vaping”) among adolescents remains a public health concern given exposure to harmful substances, plus potential association with cannabis and

Corresponding Author: Noah T. Kreski, MPH, Phone: 203-873-9660, ntk2109@cumc.columbia.edu.

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alcohol. Understanding vaping as it intersects with combustible cigarette use and other substance use can inform nicotine prevention efforts.

Methods: Data were drawn from 51,872 US adolescents (grades 8, 10, 12, years: 2017–2019) from Monitoring the Future. Multinomial logistic regression analyses assessed links of past 30-day nicotine use (none, smoking-only, vaping-only, and any smoking plus vaping) with both past 30-day cannabis use and past two-week binge drinking.

Results: Nicotine use patterns were strongly associated with greater likelihood of cannabis use and binge drinking, particularly for the highest levels of each. For instance, those who smoked and vaped nicotine had 36.53 [95% CI:16.16, 82.60] times higher odds of having 10+ past 2-week binge drinking instances compared to non-users of nicotine.

Discussion: Given the strong associations between nicotine use and both cannabis use and binge drinking, there is a need for sustained interventions, advertising and promotion restrictions, and national public education efforts to reduce adolescent nicotine vaping, efforts that acknowledge co-occurring use.

Keywords

Vaping; Adolescent; Nicotine; Trends; Substance Use

Introduction

Adolescent vaping increases risk of nicotine addiction (Amato et al., 2021; Vogel et al., 2020) and exposure to harmful toxicants (National Academies of Sciences and Medicine, 2018), and emerging evidence suggests elevated risk for sleep problems (e.g., restless or insufficient sleep) (Merianos et al., 2021; Riehm et al., 2019) and mental health symptoms, particularly depression (Becker et al., 2021; Lechner et al., 2017). Thus, while vaping may replace cigarette smoking for some adolescents (Patnode et al., 2015) and the overall health risks are lower (National Academies of Sciences and Medicine, 2018), electronic cigarettes are still harmful for adolescents (Becker et al., 2021; National Academies of Sciences and Medicine, 2018; Riehm et al., 2019; Vogel et al., 2020), and warrant ongoing surveillance. While cigarette smoking has declined among adolescents, vaping nicotine rapidly increased from 2017 to 2019 (Johnston et al., 2020; Miech et al., 2019). Nicotine vaping then stabilized in 2020 and declined in 2021 (past 30-day prevalence in grades 8/10/12 combined: 13.3%), though prevalence remains high (Miech et al., 2021; Monitoring the Future, 2022). Vaping may divert some adolescents away from cigarette smoking (Selya & Foxon, 2021; Wagner & Clifton, 2021), but the long-term impacts of vaping remain unknown, rendering the public health costs and benefits of this prevalent behavior uncertain (Wagner & Clifton, 2021).

Vaping is not an isolated substance use behavior, and combined use with other products may potentiate harms by complicating intervention efforts, strengthening other substances' effects, and increasing the physiological toll on adolescents. Adding to the negative effects of vaping, vaping nicotine is associated with use of cannabis, alcohol, and several other substances (Boccio & Jackson, 2021; Evans-Polce et al., 2020; Gilbert et al., 2021). Effectively intervening to limit a high prevalence of vaping among adolescents

requires consideration of the extent to which use of other substances complicates efforts towards reduction, especially with regard to potential dose-response relationships between substances. This study aimed to identify associations between nicotine vaping and both cannabis and binge drinking in a large, nationally-representative adolescent sample.

Methods

This study examined 51,872 US adolescents (grades:8/10/12) from Monitoring the Future (MTF) in 2017 (N=13,073), 2018 (N=13,038), and 2019 (N=25,761) (Miech et al., 2020). Data were collected annually through self-administered student surveys, yielding nationally-representative samples. MTF is approved through University of Michigan's Institutional Review Board.

To assess smoking, participants were asked "How frequently have you smoked cigarettes during the past 30 days?" In 2017 and 2018, the vaping item asked about occasions vaping nicotine during the last 30 days, while the 2019 item asked about days rather than occasions. Items were re-coded as "Any" or. "None" and combined. Dichotomous smoking and vaping items were combined (none/smoking-only/vaping-only/smoking+vaping). Binge drinking examined frequency of having 5+ drinks in the past two weeks.

Overall cannabis use was assessed as follows: "On how many occasions (if any) have you used marijuana (grass/pot) or hashish (hash/hash oil) during the last 30 days?". Cannabis vaping was assessed with items identical in phrasing and response options to the ones for nicotine vaping. Items were re-coded as "Any" or "None" and combined (none/use without vaping/use with vaping).

Demographic variables included grade, sex, race/ethnicity, parental education and urbanicity (response options are shown in Table 1).

We used survey-weighted multinomial logistic regressions to test associations between our exposure, tobacco/nicotine use, and both cannabis use and binge drinking. Three sets of models were estimated: 1. Unadjusted (Online Tables:1&4); models adjusting for demographic factors, year, and the remaining substance use item without imputation (Online Tables:2&5); and the same models with imputation (Tables:2&3). Full regression results for this last model are in Online Tables:3&6.

MTF survey weighting accounted for differing sample sizes by school/grade, selection probabilities, and over-represented 2019 data. Covariate missingness was handled in STATA 17.0 via MICE (k=5). Missingness ranged from 1.7% (binge drinking) to 19.4% (parental education).

Results

Table 1 displays the distribution of socio-demographic factors and substance use patterns within the sample. Respondents were evenly distributed across grade/sex, and most respondents were suburban, non-Hispanic White, and had a parent with a college degree.

Table 2 shows the associations between past 30-day nicotine use and the outcome of cannabis use, adjusted for demographics, year, and binge-drinking. Those who smoked cigarettes had 7.01 times the odds of cannabis use without cannabis vaping (95%CI:5.43, 9.03) and 8.03 times the odds of cannabis use that did include cannabis vaping (95%CI:5.75, 11.23) compared to those who did not use nicotine at all. Conversely, vaping-only nicotine was much more strongly associated with cannabis use that included cannabis vaping (AOR=20.31, 95%CI:17.85, 23.11) than cannabis use that did not include cannabis vaping (AOR=4.26, 95%CI:3.75, 4.85). Smoking+vaping nicotine had a strong association with cannabis use that included cannabis vaping (AOR=40.10, 95%CI:31.62, 50.86). See Online Table 1 for unadjusted ORs, Online Table 2 for unimputed.

All levels of nicotine use were associated with the outcome of binge drinking, even after adjustment (Table 3). Those who both smoked and vaped had 5.60 (95%CI:4.19, 7.48) times the odds of binge-drinking on one occasion, compared to those who did not use nicotine. For the same frequency of binge-drinking, those who only smoked nicotine had an odds ratio of 2.80 (95%CI:1.97, 3.99), while those who only vaped had an odds ratio of 4.27 (95%CI:3.56, 5.13). The association between smoking+vaping and binge drinking increased in magnitude at each increasing level of binge-drinking. See Online Table 4 for unadjusted ORs, Online Table 5 for unimputed.

Discussion

High prevalence of nicotine vaping among adolescents is an important public health concern due to the potential health consequences and strong connections between vaping and other substance use. While all levels of nicotine use are linked to cannabis use and binge drinking outcomes, associations between vaping-only or smoking+vaping and these behaviors are high, especially at the highest levels of binge drinking. The results indicate that nicotine vaping is not an isolated behavior, but rather strongly tied to other substance use that can harm adolescents and make nicotine cessation more difficult. While the causal direction of these associations is unclear, their magnitude is concerning given the harms these substances pose to adolescents (Berg et al., 2021; Lorenzetti et al., 2020; Lubman et al., 2015; Petit et al., 2014; Windle, 2003).

Nicotine vaping advertisements reach many US adolescents in retail settings and online, especially through social media (Fielding-Singh et al., 2021; Park et al., 2019; Vogel et al., 2021). This marketing is particularly impactful given the ease with which adolescents are able to acquire these devices from various sources (Mantey et al., 2019; Pepper et al., 2019; Williams et al., 2015). Availability and marketing to adolescents should be restricted, though some efforts have recently aimed to address these issues, such as the FDA requirements for health warnings on packaging and advertisements, as well as raising minimum age for e-cigarette purchase (Woodcock, 2021).

Anti-vaping campaigns targeting adolescents, like the FDA's "The Real Cost" advertisements, lower vaping intentions and promote negative views of vaping (Noar et al., 2020). Other campaigns have focused on increasing knowledge about vaping and potential harmful effects, with preliminary success (Liu et al., 2020). Novel programs are leveraging

social media and texting to engage adolescents (Graham et al., 2020; Noar et al., 2019). One program found that nearly 60% of teens who engaged with an online cessation program using texts from the perspective of a supportive friend stopped or reduced e-cigarette use (Graham et al., 2020).

This study had strengths, such as large, nationally-representative samples collected over several years. Additionally, several grade levels participated, allowing for generalization to many adolescents. Despite these strengths, our study had limitations. International generalizability is unknown. Furthermore, data were collected from students during the school day, so adolescents who were absent, homeschooled, or otherwise not in school were excluded. Nicotine vaping and smoking were assessed by self-report, and may be vulnerable to measurement and recall biases. Binge drinking should be assessed separately as 5+ drinks (boys) and 4+ (girls), rather than a uniform 5+ (Stolle et al., 2009). The data are cross-sectional, so we could not establish directionality. Patterns of cannabis use or binge drinking may lead to nicotine vaping, or additional risk factors may increase adolescents' risk of substance use more generally. Still, recognizing the strong overlap between various forms of substance use, effective intervention efforts should work to simultaneously address nicotine vaping, drinking, and cannabis use in order to encourage the health and well-being of adolescents regardless of the underlying causal structure that cannot be determined from cross sectional research.

Nicotine vaping is a highly prevalent behavior among adolescents that needs to be addressed. With strong associations between nicotine use and both cannabis use and binge drinking, there is a need for sustained interventions, advertising and promotion restrictions, and national public education efforts to reduce adolescent nicotine vaping, efforts that acknowledge co-occurring use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement:

MTF data are available in publicly accessible format.

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Table 1.

Demographic Characteristics and Outcome Distribution, 2017–2019, n=51,872

Variable	Count	Weighted/Imputed* %
Sample Size	51872	100.0
Nicotine Use, Past 30 Days		
None	43209	85.1
Smoking only	767	1.8
Vaping only	6625	10.6
Smoking and vaping	1271	2.4
Sex		
Boys	24766	48.6
Girls	25525	51.4
Race/Ethnicity		
Non-Hispanic White	25533	49.2
Non-Hispanic Black	5479	11.8
Hispanic or Latino	13371	27.9
Multiracial	2748	5.5
Non-Hispanic Asian or Pacific Islander	2896	5.6
Parental Education		
At least one college grad parent	25807	58.0
No college grad parent	16560	42.0
Urbanicity		
Urban	14879	28.6
Suburban	29244	52.9
Rural	7749	18.5
Grade		
8	17700	35.0
10	17819	36.0
12	16353	28.9
Cannabis Use, Past 30 Days		
None	42781	85.4
Use without vaping	4002	8.7
Use with vaping	3535	5.9
Binge Drinking, Past Two Weeks		
None	45000	91.1
Once	2244	4.3
Twice	1297	2.5
Three to Five Times	777	1.5
Six-Nine Times	153	0.3

Variable	Count	Weighted/Imputed* %
Ten+ Times	129	0.3

*Weighting accounted for survey design of Monitoring the Future as well as the over-representation of 2019 data. Missing data was handled with multiple imputation by chained equations in Stata (k=5). Missingness ranged from 1.7% (binge drinking) to 19.4% (parental education)

Table 2:

Associations between past 30-day nicotine and past 30-day cannabis use among US adolescents, 2017–2019

Exposure: Past 30-Day Nicotine Use	Outcome: Past 30-Day Cannabis Use	Odds Ratio*	Lower 95% Confidence Interval Limit	Upper 95% Confidence Interval Limit
Smoking Only (vs. No Use)	Without Vaping	7.01	5.43	9.03
Smoking Only (vs. No Use)	With Vaping	8.03	5.75	11.23
Vaping Only (vs. No Use)	Without Vaping	4.26	3.75	4.85
Vaping Only (vs. No Use)	With Vaping	20.31	17.85	23.11
Smoking and Vaping (vs. No Use)	Without Vaping	8.95	7.09	11.30
Smoking and Vaping (vs. No Use)	With Vaping	40.10	31.62	50.86

*Adjusted for grade, sex, race, parental education, urbanicity, binge drinking, and year

Table 3:

Associations between past 30-day nicotine use and past two-week binge drinking among US adolescents, 2017–2019

Exposure: Past 30-Day Nicotine Use	Outcome: Number of Times Binge Drinking in Past Two Weeks	Odds Ratio*	Lower 95% Confidence Interval Limit	Upper 95% Confidence Interval Limit
Smoking Only (vs. No Use)	Once	2.80	1.97	3.99
Vaping Only (vs. No Use)	Once	4.27	3.56	5.13
Smoking and Vaping (vs. No Use)	Once	5.60	4.19	7.48
Smoking Only (vs. No Use)	Twice	4.88	3.38	7.04
Vaping Only (vs. No Use)	Twice	5.23	4.20	6.52
Smoking and Vaping (vs. No Use)	Twice	12.83	9.56	17.22
Smoking Only (vs. No Use)	Three to Five	8.82	5.60	13.88
Vaping Only (vs. No Use)	Three to Five	6.45	4.71	8.85
Smoking and Vaping (vs. No Use)	Three to Five	21.60	14.89	31.33
Smoking Only (vs. No Use)	Six to Nine	5.84	1.84	18.55
Vaping Only (vs. No Use)	Six to Nine	5.75	3.09	10.70
Smoking and Vaping (vs. No Use)	Six to Nine	21.81	11.22	42.40
Smoking Only (vs. No Use)	Ten+	9.03	3.16	25.85
Vaping Only (vs. No Use)	Ten+	5.08	2.40	10.78
Smoking and Vaping (vs. No Use)	Ten+	36.53	16.16	82.60

*Adjusted for grade, sex, race, parental education, urbanicity, cannabis use, and year