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## Vaping cannabis among adolescents: prevalence and associations with tobacco use in a cross-sectional study

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Manuscripts

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3 **Vaping cannabis among adolescents: prevalence and associations with tobacco use in a**  
4 **cross-sectional study**  
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## Abstract

**Objective.** Previous research suggests that some adolescents are using e-cigarettes to vaporize (“vaping”) other substances beyond nicotine, including cannabis in the form of hash oil, THC wax or oil, or dried cannabis buds or leaves. However, it is unclear how adolescents who vape cannabis use other tobacco products. This study examined the extent to which adolescents report ever vaping cannabis and investigate how demographic variables and tobacco behaviors are associated with use.

**Design:** We used cross-sectional data of 2,835 adolescents (total response rate, 64.5%) from the 2017 North Carolina Youth Tobacco Survey. SAS logistic regression survey procedures were used to account for the complex survey design and sampling weights.

**Setting:** North Carolina, United States.

**Participants:** Adolescents in high school.

**Primary Outcome and Measure:** Adolescents were asked to indicate whether they had ever used an e-cigarette device with marijuana, THC or hash oil, or THC wax.

**Results.** Approximately one in ten high school students reported ever vaping cannabis in the overall sample (9.6%). Prevalence was significantly higher among adolescents who reported using tobacco products in the past 30 days (ranging from 28.3% among those using smokeless tobacco to 43.0% among those using waterpipe). In multivariable models, adolescents who reported using cigars (aOR: 3.76, 95% CI: 2.33, 6.07), waterpipe (aOR: 2.32, 95% CI: 1.37, 3.93), or e-cigarettes (aOR: 3.18, 95% CI: 2.38, 4.25) in the past 30 days had higher odds of reporting vaping cannabis compared to their counterparts.

**Conclusions.** These findings provide evidence that large numbers of high school students who use tobacco products have vaped cannabis. As tobacco control policies—such as communication

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campaigns or smoke-free laws—increasingly focus on e-cigarettes, attention to understanding how adolescents use e-cigarettes to vape substances other than nicotine is essential.

**Keywords:** public health; pediatrics; epidemiology

For peer review only

### Article Summary: Strengths and Limitations

- This study examined how adolescents who have ever vaped cannabis use other specific tobacco products (i.e., cigarettes, cigars, waterpipe, smokeless tobacco), which has not been done before.
- This study examined prevalence of vaping cannabis in a state that has not legalized cannabis for recreational or medicinal purposes, which has not been done before.
- The survey did not assess frequency of or current use of vaping cannabis.
- All data were self-reported.
- Results can only be generalized to adolescents in a specific state (North Carolina)

## INTRODUCTION

Although the prevalence of e-cigarette use among youth has increased dramatically in the past decade,<sup>1</sup> little epidemiologic data exist on the prevalence of using e-cigarette devices for other purposes, including vaporizing (“vaping”) cannabis in the form of hash oil, Tetrahydrocannabinol (THC) wax or oil, or dried cannabis buds or leaves.<sup>2</sup> This is surprising given that cannabis (also referred to as marijuana) and e-cigarettes are the most commonly used substances by adolescents in the US;<sup>3</sup> evidence exists that adolescents dual use both e-cigarettes and cannabis;<sup>4</sup> and longitudinal research suggests that use of e-cigarettes is associated with progression to use of cannabis.<sup>5</sup>

A growing number of studies have examined prevalence of vaping cannabis among adults<sup>6-8</sup> and adolescents<sup>9-11</sup> in the United States (US). For instance, a recent study used data from the 2016 National Youth Tobacco Survey (NYTS) and found that 8.9% of middle and high school students reported ever vaping cannabis.<sup>10</sup> Additionally, the researchers found that prevalence was higher among current e-cigarette users (39.5%) and current non-e-cigarette tobacco product users (38.5%).<sup>9,10</sup> Other studies have been conducted in Connecticut<sup>9</sup> and California<sup>11</sup> and found similar prevalence estimates. While all studies have examined how demographic factors were associated with prevalence of vaping cannabis<sup>9-11</sup> and one study examined how current e-cigarette and other tobacco product use was associated with prevalence of vaping cannabis,<sup>10</sup> no studies to our knowledge have examined how adolescents who vape cannabis use other specific tobacco products (i.e., cigarettes, cigars, waterpipe, smokeless tobacco).

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3 The FDA can now regulate the manufacture, marketing, sale, and distribution of e-  
4 cigarettes and their components, including e-liquids, cartridges, flavorings, and batteries.<sup>12</sup>  
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6 Future FDA regulations for e-cigarette may take years to implement across the US, however,  
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8 there is significant variation in state and local e-cigarette policies,<sup>13</sup> as well as state policies  
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10 related to legal access to cannabis. Therefore, to provide evidence on how youth use e-cigarettes  
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12 to vape cannabis—which can be useful to state and local authorities—we examined the  
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14 prevalence of vaping cannabis among adolescents in North Carolina—a state that has not  
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16 legalized medical or retail cannabis. Extending previous research, we examined demographic  
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18 variables and tobacco behaviors associated with use.  
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## 23 **METHODS**

### 24 **Settings, Participants, Procedures**

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26 We used data from the 2017 North Carolina Youth Tobacco Survey (NCYTS). Similar to  
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28 the NYTS,<sup>14</sup> the NCYTS is a public and charter school-based survey of students in grades 6 – 12.  
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30 A multi-stage cluster sampling design in three distinct regions of the state was used. School  
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32 districts were first selected within three geographic regions of the state; a school's probability for  
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34 selection was proportional to its enrollment size for the survey year. Classes were then randomly  
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36 selected within each school. Participation was voluntary and anonymous. Passive consent forms  
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38 were utilized, unless an active consent form was required according to a specific school district  
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40 policy. Our analyses focused on data from high school students. The overall response rate was  
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42 64.5% (75.2% school response rate, 85.8% student response rate), which is similar to the  
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44 response rate from the 2016 NYTS survey (71.6%).<sup>15</sup>  
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### 51 **Measures**



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3           *Vaping cannabis.* Our main outcome of interest was whether adolescents had used e-  
4 cigarettes to vape cannabis. Our measure of ever vaping cannabis came from the 2016 NYTS  
5 survey.<sup>10</sup> Adolescents were asked, “Have you ever used an e-cigarette device\* with a substance  
6 besides nicotine?” Participants could choose one or more of the following response options: 1)  
7 Yes, I have used an e-cigarette device with marijuana, THC or hash oil, or THC wax, 2) Yes, I  
8 have used an e-cigarette device with another substance that is not marijuana, THC or hash oil, or  
9 THC wax, 3) No, I have only used an e-cigarette device with nicotine, 4) No, I have never used  
10 an e-cigarette device, and 5) Don’t know / Not sure. If participants selected “Yes” to the first  
11 response option, they were coded as having vaped cannabis. Adolescents selecting any other  
12 response option were coded as never having vaped cannabis.

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14           *Tobacco use.* The survey assessed ever and past 30-days use of five tobacco products,  
15 including: 1) cigarettes, 2) cigars (including cigars, little cigars, and cigarillos), 3) smokeless  
16 tobacco (SLT) (including chewing tobacco, snuff, or dip; snus; and dissolvable tobacco  
17 products), 4) waterpipe (i.e., hookah), and 5) e-cigarettes. Using this information, adolescents  
18 were classified as current users of that tobacco product if they indicated that they had ever used  
19 the product and reported using it on at least one day in the past 30 days. Otherwise, participants  
20 were coded as non-current tobacco users of the product.

21  
22           *Demographics.* Demographic variables included sex (female or male), grade (9<sup>th</sup>, 10<sup>th</sup>,  
23 11<sup>th</sup>, or 12<sup>th</sup>), race/ethnicity categorized into non-Hispanic White, non-Hispanic Black, Hispanic,  
24 or non-Hispanic other race, and whether students reported receiving free or reduced-price lunch  
25 at school (yes or no).

## 26 **Statistical Analysis**

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3 Of the 3,133 high school students, we dropped data for 62 participants (2%) who had  
4 missing or inconsistent responses to whether they had vaped cannabis or not and data for 236  
5 participants (7.5%) who had missing data on any of the other variables examined, creating an  
6 analytic sample of 2,835 participants. We first examined correlates of vaping cannabis using  
7 bivariate logistic regressions. We then conducted a multivariable logistic regression, including  
8 correlates from the bivariate analyses that were statistically significant ( $p < .10$ )—an approach  
9 that has been used in previous research.<sup>16</sup> Collinearity among the tobacco use variables and  
10 demographic characteristics was low, with variance inflation factor values less than 2 for all  
11 independent variables. Correlations among tobacco use variables ranged from 0.20 to 0.47.  
12 Analyses used SAS version 9.4 survey procedures (SAS Inc., Cary, NC, USA). We set critical  $\alpha$   
13 = .05 (except as noted above) and used 2-tailed statistical tests. Results include weighted  
14 percentages, adjusted odds ratios (aOR), and 95% confidence intervals (CI).  
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### 30 **Participant Involvement**

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33 This research was done without participant involvement. Participants were not invited to  
34 comment on the study design and were not consulted to develop patient relevant outcome.  
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36 Participants were not invited to contribute to the writing or editing of this document for  
37 readability or accuracy. However, there are plans to disseminate the results of the research to NC  
38 residents, through website materials, including infographics of results.  
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### 44 **RESULTS**

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47 Approximately one in ten adolescents reported ever vaping cannabis in the overall sample  
48 (9.6%) (Table 1), which was a majority non-Hispanic White (52.8%) and even distributed by sex  
49 and grade. In addition, ever vaping cannabis was significantly associated with sex, grade, and  
50 race in bivariate results. Specifically, prevalence was significantly higher among males (11.0%)  
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3 compared to females (8.2%) (p=0.04). In addition, there was a dose response relationship  
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5 between grade and increasing prevalence of ever vaping cannabis (p<0.001)—the prevalence  
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7 among 9<sup>th</sup> grade students was 4.7% while the prevalence among 12<sup>th</sup> grade students was 15.5%.  
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9 Moreover, prevalence was higher among non-Hispanic white students (11.3%), Hispanic  
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11 students (10.5%), and non-Hispanic other students (11.8%), compared to non-Hispanic Black  
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13 students (5.0%) (p=0.02). Finally, prevalence was significantly higher among adolescents who  
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15 reported using cigarettes, cigars, SLT, waterpipe, or e-cigarettes in the past 30 days (ranging  
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17 from 28.3% among those using SLT to 43.0% among those using waterpipe), all p-values  
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19 <0.001.  
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24 In multivariable models (Table 2), 10<sup>th</sup> grade students (aOR: 1.87, 95% CI: 1.01, 3.47),  
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26 11<sup>th</sup> grade students (aOR: 1.99, 95% CI: 1.21, 3.26), and 12<sup>th</sup> grade students (aOR: 2.88, 95% CI:  
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28 1.46, 5.67) had higher odds of ever vaping cannabis than 9<sup>th</sup> grade students. In addition,  
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30 adolescents who reported using cigars (aOR: 3.76, 95% CI: 2.33, 6.07), waterpipe (aOR: 2.32,  
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32 95% CI: 1.37, 3.93), or e-cigarettes (aOR: 3.18, 95% CI: 2.38, 4.25) in the past 30 days had  
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34 higher odds of reporting ever vaping cannabis than adolescents not using those products in the  
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36 past 30 days.  
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## 40 DISCUSSION

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42 This is one of a growing number of research studies to show that many high school  
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44 students who use tobacco products have vaped cannabis. Compared to previous research, we  
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46 found a similar prevalence of vaping cannabis among adolescents (9.6% in our study compared  
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48 to 5.4%,<sup>9</sup> 8.2%,<sup>17</sup> 8.9%<sup>10</sup>, and 10.5%<sup>11</sup> in previous research). Using current NC enrollment  
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50 figures, our findings suggest that over 46,000 high school students across the state have ever  
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52 vaped cannabis. Moreover, in some sub-groups (i.e., current waterpipe users), prevalence of  
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3 vaping cannabis rose to 43%. These findings provide additional evidence that large numbers of  
4 adolescents—particularly those who currently use tobacco—are also vaping cannabis, even in  
5 states where cannabis use is not legal.  
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10 The health effects of vaping cannabis are not yet known. Some research suggests that  
11 vaping cannabis may be associated with fewer respiratory symptoms than smoking cannabis,<sup>2,18</sup>  
12 however, this does not mean that vaping cannabis is safe<sup>19</sup>—particularly if it leads to earlier  
13 initiation of tobacco or cannabis use, increased frequency of use or misuse, increased potency of  
14 cannabis, or concomitant tobacco and cannabis use.<sup>2,8,19</sup> Moreover, since vaping is so new, few  
15 long-term investigations have been conducted on its safety.  
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24 The high number of high school students who have used an e-cigarette to vape cannabis  
25 is concerning, as many tobacco control policies and interventions, such as smoke-free laws, do  
26 not extend to e-cigarettes,<sup>20</sup> let alone using e-cigarettes for other substances, such as cannabis.  
27 Even though some states, such as Colorado, have included cannabis in smoke-free laws,<sup>21</sup> these  
28 laws do not cover vaping or vaping cannabis.<sup>22</sup> As tobacco control policies—such as national  
29 communication campaigns<sup>23</sup> or smoke-free laws<sup>20</sup>—begin focusing on e-cigarettes, attention to  
30 how e-cigarettes can be used for use of other substances is warranted.  
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40 Moreover, since many people believe that vaping cannabis is a safer way to use cannabis  
41 than other modes of administration (e.g., smoking),<sup>2</sup> communication messages on actual safety  
42 should be reported. While these data are not yet available, two countries (Uruguay and Canada)  
43 have already legalized cannabis for recreational purposes. Findings from legalization in these  
44 countries, which represent large-scale naturalized experiments, will offer insights into the safety  
45 of cannabis, effects of legalization on use, and/or other public health implications of legalization  
46 (e.g., prevalence of car accidents).  
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## Limitations

Some limitations of the data exist, including that: the survey included only one item to assess vaping cannabis, did not assess frequency of or current use of vaping cannabis; did not provide examples of specific products (“JuJu Joint”); and did not assess current or ever use of cannabis without an e-cigarette device, which is similar to other tobacco use questionnaires.<sup>14</sup> All data were self-reported, hence are subject to related biases. Lastly, results can only be generalizable to adolescents in a specific state (North Carolina).

## Conclusions

Findings suggest that adolescent cannabis vaping is an important public health issue that is likely to affect and be affected by tobacco control and cannabis policies in states and at the federal level in the US.<sup>24</sup> With North Carolina currently introducing legislature to make to legal to possess medical cannabis, our study among NC high school students is particularly relevant. Future research is needed to investigate how youth use e-cigarette devices for other purposes beyond vaping nicotine.

## Footnote:

\*In a previous section of the survey, e-cigarettes were described as “battery powered devices that usually contain a nicotine-based liquid that is vaporized and inhaled. You may know them as vape-pens, hookah-pens, e-hookahs, e-cigars, e-pipes, personal vaporizers or mods. Some brand examples include NJOY, Blu, Vuse, MarkTen, Logic, Vapin Plus, eGo and and Halo.”

## Additional Information

**Author Contributions.** Dr. Kowitt had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

*Study concept and design:* Kowitt

*Acquisition, analysis, or interpretation of data:* All authors

*Drafting of the manuscript:* Kowitt

*Critical revision of the manuscript for important intellectual content:* All authors

*Statistical analysis:* Kowitt

*Obtained funding:* Goldstein, Ranney, Martin

*Administrative, technical, or material support:* All authors

*Study supervision:* Goldstein

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**Competing interests.** The authors have no competing interests to declare.

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3 **Statement of Ethical Approval.** With regard to ethical approval, our study used secondary, de-  
4 identified data and did not constitute human subjects research as defined under federal  
5 regulations 45 CFR 46.102 (d or f) and 21 CFR 56.102(c)(e)(l); hence, this study did not require  
6 Institutional Review Board approval.  
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12 **Previous presentation of the information reported in the manuscript.** None.  
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14 **Data sharing.** Data will be made available upon request.  
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Table 1. Weighted participant characteristics stratified by ever vaping cannabis status, n=2,835, data collected from the 2017 North Carolina Youth Tobacco Survey

Variable	Total Sample, n=2,835 n (%)	Has never vaped cannabis, n=2,582 n (%)	Has ever vaped cannabis, n=253 n (%)	p-value
Ever used an e-cigarette to vape cannabis				
No	2582 (90.4)	--	--	
Yes	253 (9.6)	--	--	
Sex				
Female	1428 (51.2)	1323 (91.8)	105 (8.2)	p=0.04
Male	1407 (48.8)	1259 (89.0)	148 (11.0)	
Grade				
9 <sup>th</sup>	904 (28.7)	856 (95.3)	48 (4.7)	p<0.001
10 <sup>th</sup>	696 (26.2)	638 (90.9)	58 (9.1)	
11 <sup>th</sup>	577 (24.0)	515 (89.4)	62 (10.6)	
12 <sup>th</sup>	658 (21.0)	573 (84.5)	85 (15.5)	
Race				
Non-Hispanic White	1503 (52.8)	1352 (88.7)	151 (11.3)	p=0.02
Non-Hispanic Black	650 (26.0)	617 (95.0)	33 (5.0)	
Hispanic	517 (14.1)	468 (89.5)	49 (10.5)	
Non-Hispanic other	167 (7.2)	145 (88.2)	20 (11.8)	
Free or reduced-price lunch				
Yes	1362 (44.1)	1249 (90.1)	113 (9.9)	p=0.73
No	1473 (55.9)	1333 (90.7)	140 (9.3)	
Current cigarette use				
No	2617 (92.7)	2436 (92.2)	181 (7.8)	p<0.001
Yes	218 (7.3)	146 (67.8)	72 (32.2)	
Current cigar use				
No	2497 (88.9)	2346 (93.6)	151 (6.4)	p<0.001
Yes	338 (11.1)	236 (65.2)	102 (34.8)	
Current smokeless tobacco use				
No	2649 (94.3)	2451 (91.6)	198 (8.4)	p<0.001
Yes	186 (5.7)	131 (71.7)	55 (28.3)	
Current waterpipe use				
No	2722 (96.6)	2516 (91.6)	206 (8.4)	p<0.001
Yes	113 (3.4)	66 (57.0)	47 (43.0)	
Current e-cigarette use				
No	2334 (84.2)	2217 (94.2)	117 (5.8)	p<0.001
Yes	501 (15.8)	365 (70.7)	136 (29.3)	



Table 2. Weighted multivariable logistic regression results, <sup>a,b</sup> n=2,835, data collected from the 2017 North Carolina Youth Tobacco Survey

Variable	aOR (95% CI)
Male (ref. female)	1.33 (0.87, 2.04)
10 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>1.87 (1.01, 3.47)</b>
11 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>1.99 (1.21, 3.26)</b>
12 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>2.88 (1.46, 5.67)</b>
Black (ref. non-Hispanic White)	0.51 (0.22, 1.16)
Hispanic (ref. non-Hispanic White)	1.03 (0.78, 1.38)
Other race (ref. non-Hispanic White)	1.38 (0.72, 2.64)
Current cigarette use (ref. no current use)	1.27 (0.71, 2.29)
Current cigar use (ref. no current use)	<b>3.76 (2.33, 6.07)</b>
Current smokeless tobacco use (ref. no current use)	0.89 (0.42, 1.91)
Current waterpipe use (ref. no current use)	<b>2.32 (1.37, 3.93)</b>
Current e-cigarette use (ref. no current use)	<b>3.18 (2.38, 4.25)</b>
<sup>a</sup> Only variables that were statistically significant ( $p < 0.10$ ) in bivariate analyses were included in the multivariable model (i.e., sex, grade, race, current use of cigarettes, cigars, smokeless tobacco, waterpipe, or e-cigarettes, and ever use of e-cigarettes).	
<sup>b</sup> Boldface indicates significance $p < 0.05$	

## References

1. U.S. Department of Health and Human Services. E-Cigarette Use Among Youth and Young Adults: A Report of the Surgeon General. 2016. Available at: [https://e-cigarettes.surgeongeneral.gov/documents/2016\\_SGR\\_Full\\_Report\\_non-508.pdf](https://e-cigarettes.surgeongeneral.gov/documents/2016_SGR_Full_Report_non-508.pdf). Accessed August 15, 2017.
2. Budney AJ, Sargent JD, Lee DC. Vaping cannabis (marijuana): parallel concerns to e-cigs? *Addiction*. Nov 2015;110(11):1699-1704.
3. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. Monitoring the Future National Survey Results on Drug Use, 1975-2016: Key Findings on Adolescent Drug Use. Ann Arbor, MI: Institute for Social Research, The University of Michigan. 2017. Available at: <http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2016.pdf>. Accessed June 28, 2018.
4. Dai H, Hao J. Electronic cigarette and marijuana use among youth in the United States. *Addict Behav*. Mar 2017;66:48-54.
5. Dai H, Catley D, Richter KP, Goggin K, Ellerbeck EF. Electronic Cigarettes and Future Marijuana Use: A Longitudinal Study. *Pediatrics*. May 2018;141(5).
6. Schauer GL, King BA, Bunnell RE, Promoff G, McAfee TA. Toking, Vaping, and Eating for Health or Fun: Marijuana Use Patterns in Adults, U.S., 2014. *Am J Prev Med*. Jan 2016;50(1):1-8.
7. Lee DC, Crosier BS, Borodovsky JT, Sargent JD, Budney AJ. Online survey characterizing vaporizer use among cannabis users. *Drug Alcohol Depend*. Feb 1 2016;159:227-233.
8. Morean ME, Lipshie N, Josephson M, Foster D. Predictors of Adult E-Cigarette Users Vaporizing Cannabis Using E-Cigarettes and Vape-Pens. *Subst Use Misuse*. Jul 3 2017;52(8):974-981.
9. Morean ME, Kong G, Camenga DR, Cavallo DA, Krishnan-Sarin S. High School Students' Use of Electronic Cigarettes to Vaporize Cannabis. *Pediatrics*. Oct 2015;136(4):611-616.
10. Trivers KF, Phillips E, Gentzke AS, Tynan MA, Neff LJ. Prevalence of Cannabis Use in Electronic Cigarettes Among US Youth. *JAMA Pediatr*. Nov 1 2018;172(11):1097-1099.
11. Peters EN, Bae D, Barrington-Trimis JL, Jarvis BP, Leventhal AM. Prevalence and Sociodemographic Correlates of Adolescent Use and Polyuse of Combustible, Vaporized, and Edible Cannabis Products. *JAMA Network Open*. 2018;1(5):e182765-e182765.
12. U.S. Food and Drug Administration. Vaporizers, e-Cigarettes, and other electronic nicotine delivery systems (ENDS). 2017. Available at: <https://www.fda.gov/TobaccoProducts/Labeling/ProductsIngredientsComponents/ucm456610.htm#reporting>. Accessed 06/07/2017.
13. Public Health Law Center at Mitchell Hamline School of Law. U.S. E-Cigarette Regulations - 50 State Review (2016). 2016. Available at: <http://publichealthlawcenter.org/resources/us-e-cigarette-regulations-50-state-review>. Accessed August 4, 2016.
14. Centers for Disease Control and Prevention. National Youth Tobacco Survey (NYTS). 2015. Available at: [http://www.cdc.gov/tobacco/data\\_statistics/surveys/nyts/](http://www.cdc.gov/tobacco/data_statistics/surveys/nyts/). Accessed 03/22/2015.
15. Wang TW, Gentzke A, Sharapova S, Cullen KA, Ambrose BK, Jamal A. Tobacco Product Use Among Middle and High School Students - United States, 2011-2017. *MMWR Morb Mortal Wkly Rep*. Jun 8 2018;67(22):629-633.

16. Hall MG, Ribisl KM, Brewer NT. Smokers' and nonsmokers' beliefs about harmful tobacco constituents: implications for FDA communication efforts. *Nicotine Tob Res.* 2014;16(3):343-350.
17. Mammen G, Rehm J, Rueda S. Vaporizing cannabis through e-cigarettes: Prevalence and socio-demographic correlates among Ontario high school students. *Can J Public Health.* 2016;107(3):337-338.
18. Earleywine M, Barnwell SS. Decreased respiratory symptoms in cannabis users who vaporize. *Harm Reduct J.* Apr 16 2007;4:11.
19. Cox B. Can the research community respond adequately to the health risks of vaping? *Addiction.* Nov 2015;110(11):1708-1709.
20. Campaign for Tobacco Free Kids. Electronic cigarettes should be included in smoke-free laws 2018. Available at: <https://www.tobaccofreekids.org/assets/factsheets/0387.pdf>. Accessed June 18, 2018.
21. Ghosh T, Van Dyke M, Maffey A, Whitley E, Gillim-Ross L, Wolk L. The public health framework of legalized marijuana in Colorado. *Am J Public Health.* 2016;106(1):21-27.
22. Garcia AD. City attorney: There's no reason Denver couldn't allow marijuana vaping. 2017. Available at: <https://denverite.com/2017/02/08/theres-no-reason-denver-couldnt-allow-marijuana-vaping/>. Accessed June 18, 2018.
23. U.S. Food and Drug Administration. The Real Cost Campaign. 2018. Available at: <https://www.fda.gov/tobaccoproducts/publichealtheducation/publiceducationcampaigns/therealcostcampaign/default.htm>. Accessed April 30, 2018.
24. Marijuana Policy Project. Medical Marijuana Bills Pending. 2018. Available at: <https://www.mpp.org/states/north-carolina/>. Accessed August 6, 2018.

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	<b>Item No</b>	<b>Recommendation</b>	<b>Assessed</b>
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Yes, pg 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes, pg 2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes, pg 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes, pg 6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Yes, pg 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes, pg 6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Yes, pg 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes, pg 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes, pg 7
Bias	9	Describe any efforts to address potential sources of bias	Yes, pg 7 (control variables)
Study size	10	Explain how the study size was arrived at	Yes, pg 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes, pg 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Yes, pg 8
		(b) Describe any methods used to examine subgroups and interactions	N/A
		(c) Explain how missing data were addressed	Yes, pg 8
		(d) If applicable, describe analytical methods taking account of sampling strategy	No
		(e) Describe any sensitivity analyses	No
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	No
		(b) Give reasons for non-participation at each stage	No
		(c) Consider use of a flow diagram	No

1			
2	Descriptive data	14*	(a) Give characteristics of study participants (eg
3			demographic, clinical, social) and information on
4			exposures and potential confounders
5			
6			(b) Indicate number of participants with missing data for
7			each variable of interest
8	Outcome data	15*	Report numbers of outcome events or summary measures
9			
10	Main results	16	(a) Give unadjusted estimates and, if applicable,
11			confounder-adjusted estimates and their precision (eg, 95%
12			confidence interval). Make clear which confounders were
13			adjusted for and why they were included
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15			(b) Report category boundaries when continuous variables
16			were categorized
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18			(c) If relevant, consider translating estimates of relative risk
19			into absolute risk for a meaningful time period
20	Other analyses	17	Report other analyses done—eg analyses of subgroups and
21			interactions, and sensitivity analyses
22			
23	<b>Discussion</b>		
24	Key results	18	Summarise key results with reference to study objectives
25	Limitations	19	Discuss limitations of the study, taking into account
26			sources of potential bias or imprecision. Discuss both
27			direction and magnitude of any potential bias
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29	Interpretation	20	Give a cautious overall interpretation of results considering
30			objectives, limitations, multiplicity of analyses, results
31			from similar studies, and other relevant evidence
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33	Generalisability	21	Discuss the generalisability (external validity) of the study
34			results
35			
36	<b>Other information</b>		
37	Funding	22	Give the source of funding and the role of the funders for
38			the present study and, if applicable, for the original study
39			on which the present article is based
40			

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Vaping cannabis among adolescents: prevalence and associations with tobacco use from a cross-sectional study in the United States

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3 **Vaping cannabis among adolescents: prevalence and associations with tobacco use from a**  
4 **cross-sectional study in the United States**  
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## Abstract

**Objective.** Previous research suggests that some adolescents are using e-cigarette devices to vaporize (“vaping”) cannabis in the form of hash oil, THC wax or oil, or dried cannabis buds or leaves. However, it is unclear how adolescents who vape cannabis use other tobacco products.

This study examined the extent to which adolescents reported ever vaping cannabis and investigated how demographic variables and tobacco behaviors were associated with use.

**Design:** We used cross-sectional data from adolescents (total response rate, 64.5%) who participated in the 2017 North Carolina Youth Tobacco Survey. SAS logistic regression survey procedures were used to account for the complex survey design and sampling weights.

**Setting:** North Carolina, United States.

**Participants:** Adolescents in high school (n=2,835).

**Primary Outcome and Measure:** Adolescents were asked to indicate whether they had ever used an e-cigarette device with marijuana, THC or hash oil, or THC wax.

**Results.** Approximately one in ten high school students reported ever vaping cannabis in the overall sample (9.6%). In multivariable models, adolescents who reported using cigars (aOR: 3.76, 95% CI: 2.33, 6.07), waterpipe (aOR: 2.32, 95% CI: 1.37, 3.93), or e-cigarettes (aOR: 3.18, 95% CI: 2.38, 4.25) in the past 30 days had higher odds of reporting ever vaping cannabis compared to their counterparts. There was no significant association between use of smokeless tobacco (aOR: 0.89, 95% CI: 0.42, 1.91) or use of cigarettes (aOR: 1.27, 95% CI: 0.71, 2.29) in the past 30 days and odds of reporting ever vaping cannabis.

**Conclusions.** These findings provide evidence that large numbers of high school students who use tobacco products have vaped cannabis. As tobacco control policies—such as communication



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campaigns or smoke-free laws—increasingly focus on e-cigarettes, attention to understanding how adolescents use e-cigarettes to vape substances other than nicotine is essential.

**Keywords:** public health; pediatrics; epidemiology

For peer review only

### Article Summary: Strengths and Limitations

- The survey did not assess frequency or current use of vaping cannabis.
- The survey did not provide relevant examples of products used to vape cannabis (e.g., “JuJu Point” or “Pax”).
- We are unable to assess whether participants used tobacco e-cigarettes for cannabis or specialized cannabis devices.
- Results can only be generalized to adolescents in a specific state (North Carolina).
- Our measure of vaping cannabis has been used previously in nationally representative surveys in the United States.

## INTRODUCTION

Although the prevalence of e-cigarette use among youth has increased dramatically in the past decade,<sup>1</sup> little epidemiologic data exist on the prevalence of using e-cigarette devices or other specialized devices to vaporize (“vape”) cannabis in the form of hash oil, Tetrahydrocannabinol (THC) wax or oil, or dried cannabis buds or leaves.<sup>2</sup> This is surprising given that 1) cannabis (also referred to as marijuana) and e-cigarettes are the most commonly used substances by adolescents in the US,<sup>3</sup> 2) evidence exists that adolescents dual use both tobacco e-cigarettes and cannabis,<sup>4</sup> and 3) longitudinal research suggests that use of e-cigarettes is associated with progression to use of cannabis.<sup>5</sup>

A growing number of studies have examined prevalence of vaping cannabis among adults<sup>6-8</sup> and adolescents<sup>9-11</sup> in the United States (US). For instance, a recent study used data from the 2016 National Youth Tobacco Survey (NYTS) and found that 8.9% of middle and high school students reported ever vaping cannabis.<sup>10</sup> Additionally, the researchers found that prevalence was higher among current e-cigarette users (39.5%) and current non-e-cigarette tobacco product users (38.5%).<sup>9,10</sup> Other studies have been conducted in Connecticut<sup>9</sup> and California<sup>11</sup> and found similar prevalence estimates. While all studies have examined how demographic factors were associated with prevalence of vaping cannabis<sup>9-11</sup> and one study examined how current e-cigarette and other tobacco product use was associated with prevalence of vaping cannabis,<sup>10</sup> no studies to our knowledge have examined how adolescents who vape cannabis use other specific tobacco products (i.e., cigarettes, cigars, waterpipe, smokeless tobacco).

The FDA can now regulate the manufacture, marketing, sale, and distribution of e-cigarettes and their components, including e-liquids, cartridges, flavorings, and batteries.<sup>12</sup>

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3 Future FDA regulations for e-cigarettes may take years to implement across the US, however,  
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5 there is significant variation in state and local e-cigarette policies,<sup>13</sup> as well as state policies  
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7 related to legal access to cannabis. Therefore, to provide evidence on how youth use e-cigarettes  
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9 to vape cannabis—which can be useful to state and local authorities—we examined the  
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11 prevalence of vaping cannabis among adolescents in North Carolina—a state that has not  
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13 legalized medical or retail cannabis for adults. Extending previous research, we examined  
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15 demographic variables and tobacco behaviors associated with use.  
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## 18 19 **METHODS**

### 20 21 **Settings, Participants, Procedures**

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23 We used data from the 2017 North Carolina Youth Tobacco Survey (NCYTS). Similar to  
24  
25 the NYTS,<sup>14</sup> the NCYTS is a public and charter school-based survey of students in grades 6 – 12.  
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27 A multi-stage cluster sampling design in three distinct regions of the state was used. School  
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29 districts were first selected within three geographic regions of the state; a school’s probability for  
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31 selection was proportional to its enrollment size for the survey year. Classes were then randomly  
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33 selected within each school. Participation was voluntary and anonymous. Passive consent forms  
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35 were utilized, unless an active consent form was required according to a specific school district  
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37 policy. Our analyses focused on data from high school students. The overall response rate was  
38  
39 64.5% (75.2% school response rate, 85.8% student response rate), which is similar to the  
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41 response rate from the 2016 NYTS survey (71.6%).<sup>15</sup>  
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### 46 47 **Measures**

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49 *Vaping cannabis.* Our main outcome of interest was whether adolescents had used e-  
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51 cigarette devices to vape cannabis. Our measure of ever vaping cannabis came from the 2016  
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53 NYTS survey.<sup>10</sup> Adolescents were asked, “Have you ever used an e-cigarette device with a  
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3 substance besides nicotine?” Participants could choose one or more of the following response  
4 options: 1) Yes, I have used an e-cigarette device with marijuana, THC or hash oil, or THC wax,  
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6 2) Yes, I have used an e-cigarette device with another substance that is not marijuana, THC or  
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8 hash oil, or THC wax, 3) No, I have only used an e-cigarette device with nicotine, 4) No, I have  
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10 never used an e-cigarette device, and 5) Don’t know / Not sure. If participants selected “Yes” to  
11  
12 the first response option, they were coded as having vaped cannabis. Adolescents selecting any  
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14 other response option were coded as never having vaped cannabis.  
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19 In a previous section of the survey, e-cigarettes were described as “battery powered  
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21 devices that usually contain a nicotine-based liquid that is vaporized and inhaled. You may know  
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23 them as vape-pens, hookah-pens, e-hookahs, e-cigars, e-pipes, personal vaporizers or mods.  
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25 Some brand examples include NJOY, Blu, Vuse, MarkTen, Logic, Vapin Plus, eGo and Halo.”  
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28 *Tobacco use.* The survey assessed ever and past 30-days use of five tobacco products,  
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30 including: 1) cigarettes, 2) cigars (including cigars, little cigars, and cigarillos), 3) smokeless  
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32 tobacco (SLT) (including chewing tobacco, snuff, or dip; snus; and dissolvable tobacco  
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34 products), 4) waterpipe (i.e., hookah), and 5) e-cigarettes. Using this information, adolescents  
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36 were classified as current users of that tobacco product if they indicated that they had ever used  
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38 the product and reported using it on at least one day in the past 30 days. Otherwise, participants  
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40 were coded as non-current tobacco users of the product.  
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44 *Demographics.* Demographic variables included sex (female or male), grade (9<sup>th</sup>, 10<sup>th</sup>,  
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46 11<sup>th</sup>, or 12<sup>th</sup>), race/ethnicity categorized into non-Hispanic White, non-Hispanic Black, Hispanic,  
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48 or non-Hispanic other race, and whether students reported receiving free or reduced-price lunch  
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50 at school (yes or no).  
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### 53 **Statistical Analysis**

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3 Of the 3,133 high school students, we dropped data for 62 participants (2%) who had  
4 missing or inconsistent responses to whether they had vaped cannabis or not and data for 236  
5 participants (7.5%) who had missing data on any of the other variables examined, creating an  
6 analytic sample of 2,835 participants. We first examined correlates of vaping cannabis using  
7 bivariate chi-square tests. We then conducted a multivariable logistic regression, including  
8 correlates from the bivariate analyses with  $p < .10$ —an approach that has been used in previous  
9 research.<sup>16</sup> Collinearity among the tobacco use variables and demographic characteristics was  
10 low, with variance inflation factor values less than 2 for all independent variables. Correlations  
11 among tobacco use variables, calculated using phi coefficients, which are measures of  
12 association between dichotomous variables, ranged from 0.20 to 0.47. Analyses used SAS  
13 version 9.4 survey procedures (SAS Inc., Cary, NC, USA). We set critical  $\alpha = .05$  and used 2-  
14 tailed statistical tests. Results include weighted percentages, adjusted odds ratios (aOR), and  
15 95% confidence intervals (CI).  
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### 32 **Participant Involvement**

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34 This research was done without participant involvement. Participants were not invited to  
35 comment on the study design and were not consulted to develop patient relevant outcome.  
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37 Participants were not invited to contribute to the writing or editing of this document for  
38 readability or accuracy. However, there are plans to disseminate the results of the research to  
39 North Carolina residents, through website materials and infographics of results.  
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### 47 **RESULTS**

48  
49 Approximately one in ten adolescents reported ever vaping cannabis in the overall sample  
50 (9.6%) (Table 1), which was a majority non-Hispanic White (52.8%) and evenly distributed by  
51 sex and grade. Ever vaping cannabis was significantly associated with sex, grade, and race in  
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bivariate results. Specifically, prevalence was significantly higher among males (11.0%) compared to females (8.2%) ( $p=0.04$ ). In addition, grade was associated with prevalence of ever vaping cannabis ( $p<0.001$ ), such that as grade increased, prevalence of ever vaping cannabis increased. Specifically, the prevalence among 9<sup>th</sup> grade students was 4.7% while the prevalence among 12<sup>th</sup> grade students was 15.5%. Prevalence was higher among non-Hispanic white students (11.3%), Hispanic students (10.5%), and non-Hispanic other students (11.8%), compared to non-Hispanic Black students (5.0%) ( $p=0.02$ ). Finally, prevalence was significantly higher among adolescents who reported using cigarettes, cigars, SLT, waterpipe, or tobacco e-cigarettes in the past 30 days (ranging from 28.3% among those using SLT to 43.0% among those using waterpipe), all  $p$ -values  $<0.001$ .

In multivariable models (Table 2), 10<sup>th</sup> grade students (aOR: 1.87, 95% CI: 1.01, 3.47), 11<sup>th</sup> grade students (aOR: 1.99, 95% CI: 1.21, 3.26), and 12<sup>th</sup> grade students (aOR: 2.88, 95% CI: 1.46, 5.67) had higher odds of ever vaping cannabis than 9<sup>th</sup> grade students. In addition, adolescents who reported using cigars (aOR: 3.76, 95% CI: 2.33, 6.07), waterpipe (aOR: 2.32, 95% CI: 1.37, 3.93), or tobacco e-cigarettes (aOR: 3.18, 95% CI: 2.38, 4.25) in the past 30 days had higher odds of reporting ever vaping cannabis than adolescents not using those products in the past 30 days. There was no significant association between use of SLT (aOR: 0.89, 95% CI: 0.42, 1.91) or use of cigarettes (aOR: 1.27, 95% CI: 0.71, 2.29) in the past 30 days and odds of reporting ever vaping cannabis.

## DISCUSSION

This is one of a growing number of research studies to show that many high school students who use tobacco products have vaped cannabis. Compared to previous research, we found a similar prevalence of vaping cannabis among adolescents: 9.6% in our study of North

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3 Carolina high school students who were mostly between the ages of 14-18, compared to 5.4% in  
4 a sample of high school students in Connecticut,<sup>9</sup> 8.2% in a sample of high school students in  
5 Canada aged 15-18,<sup>17</sup> 8.9% in a sample of middle and high school students in the US<sup>10</sup>, and  
6 10.5% in a sample of 10<sup>th</sup> graders in California<sup>11</sup> in previous research). Using current North  
7 Carolina enrollment figures, our findings suggest that over 46,000 high school students across  
8 the state have ever vaped cannabis. Moreover, in some sub-groups (i.e., current waterpipe users),  
9 prevalence of ever vaping cannabis rose to 43%. These findings provide additional evidence that  
10 large numbers of adolescents—particularly those who currently use tobacco—are also vaping  
11 cannabis, even in areas where cannabis use is not legal for any adult.  
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24 The health effects of vaping cannabis are not yet known. Some research suggests that  
25 vaping cannabis may be associated with fewer respiratory symptoms than smoking cannabis.<sup>2,18</sup>  
26 However, this does not mean that adolescents' use of vaporized cannabis is safe<sup>19</sup>—particularly  
27 if it leads to earlier initiation of tobacco or cannabis use, concomitant tobacco and cannabis use  
28 increased frequency of use or misuse of tobacco or cannabis, or increased potency of  
29 cannabis.<sup>2,8,19</sup> In addition, there are also concerns that qualities of non-combustible forms of  
30 cannabis (e.g., availability of flavorings, no smell of smoke, lower harm perceptions) may attract  
31 youth who would otherwise not use combustible forms of cannabis. In a study of 10<sup>th</sup> graders in  
32 Los Angeles, California, researchers found that 7.8% had never smoked combustible cannabis  
33 but had used vaporized or edible cannabis.<sup>11</sup> It is possible that these adolescents would never  
34 have used cannabis if non-combustible forms of cannabis had not been available, although no  
35 research, to our knowledge, has examined this hypothesis. As has been done with e-cigarettes,<sup>20</sup>  
36 more research and simulation models are needed to quantify the population-level benefits and  
37 harms of non-combustible forms of cannabis, including the effects of vaporized cannabis use on  
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3 combustible cannabis use and use of other tobacco products. In other words, can vaporized  
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5 cannabis divert adolescents from smoking cannabis, does the availability and acceptability of  
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7 vaporized cannabis attract new adolescents to begin using cannabis who would not have  
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9 otherwise used it, and does vaporized cannabis influence other tobacco use, including tobacco e-  
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11 cigarette use?  
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15 Recent data from Monitoring the Future, a large study of youth and young adults in the  
16  
17 US, suggests that prevalence of vaping cannabis increased from 2017 to 2018 among 8<sup>th</sup> graders,  
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19 10<sup>th</sup> graders, and 12<sup>th</sup> graders.<sup>21, p. 76</sup> This finding, coupled with the number of high school  
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21 students who have used an e-cigarette device to vape cannabis in the current study, is concerning  
22  
23 to the researchers. Many tobacco control policies and interventions, such as smoke-free laws, do  
24  
25 not extend to e-cigarettes,<sup>22</sup> let alone using e-cigarettes for other substances, such as cannabis.  
26  
27 Even though some states, such as Colorado, have included cannabis in smoke-free laws,<sup>23</sup> these  
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29 laws do not cover vaping or vaping cannabis.<sup>24</sup> As tobacco control policies—such as national  
30  
31 communication campaigns<sup>25</sup> or smoke-free laws<sup>22</sup>—begin focusing on e-cigarettes, attention to  
32  
33 how e-cigarettes can be used for use of other substances is warranted. As more states and  
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35 countries around the world begin to legalize marijuana for medicinal and recreational purposes,  
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37 lessons learned from tobacco and alcohol regulation should be applied.<sup>26</sup>  
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43 Moreover, since many people believe that vaping cannabis is a safer way to use cannabis  
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45 than other modes of administration (e.g., smoking),<sup>2</sup> communication messages on actual safety  
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47 should be reported. While these data are not yet available, two countries—Uruguay and  
48  
49 Canada—have already legalized cannabis for recreational purposes, although neither country has  
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51 legalized sales of non-combustible forms of cannabis yet. In addition, among the US states that  
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53 have legalized medical marijuana for adults, Utah legalized only non-combustible forms of  
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3 marijuana, including vaporized cannabis and edibles.<sup>27</sup> Findings from legalization in these areas,  
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5 which represent large-scale naturalized experiments, will offer insights into the safety of  
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7 cannabis, effects of legalization on use, and/or other public health implications of legalization  
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9 (e.g., prevalence of car accidents). Data from Utah, in particular, may be useful for answering  
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11 research questions on trends, correlates, and consequences of non-combustible forms of cannabis  
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13 (i.e., vaporized cannabis).  
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### 15 16 17 **Limitations**

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19 Some limitations of the data exist. First, the survey included only one item to assess  
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21 vaping cannabis, did not assess frequency of or current use of vaping cannabis, did not provide  
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23 examples of specific products used to vape cannabis (e.g., “JuJu Joint” or “Pax”), and did not  
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25 assess current or ever use of cannabis without an e-cigarette device. Given these limitations, we  
26  
27 were unable to examine more complex patterns of vaping cannabis, such as: prevalence and  
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29 frequency of vaping cannabis in the past 30 days, the prevalence of vaping cannabis among  
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31 cannabis users, and cannabis-related variables (e.g., harm perceptions of cannabis) that could be  
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33 associated with vaping cannabis. Future analyses using larger datasets in the US, such as  
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35 Monitoring the Future, and worldwide could help answer research questions that the current  
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37 study was not able to assess.  
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42 Second, the item used to assess prevalence of vaping cannabis asked about use of an “e-  
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44 cigarette device with marijuana, THC or hash oil, or THC wax.” We are therefore unable to  
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46 assess whether participants used tobacco e-cigarettes for cannabis or whether they used  
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48 specialized cannabis devices. Relatedly, while the item used to assess prevalence of vaping  
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50 cannabis in our study has been used previously in nationally representative surveys,<sup>10</sup> no studies,  
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3 to our knowledge, have used observational or biological indicators to verify reports of vaping  
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5 cannabis.  
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8 Third, prior to the question about ever vaping cannabis, the survey defined what an e-  
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10 cigarette device was and provided examples of brand names (NJOY, MarkTen). This list did not  
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12 include JUUL as an e-cigarette brand name, which is an important limitation given that JUUL  
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14 became the most popular e-cigarette by the end of 2017,<sup>28</sup> and the description of e-cigarettes did  
15  
16 not include any cannabis vaporizers.  
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20 Fourth, it is possible that students included in the final sample with complete data  
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22 differed from those not included in the final sample. Indeed, in an attrition analysis (see  
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24 Supplementary Table A), we found that a higher proportion of females, non-Hispanic White  
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26 adolescents, and non-current tobacco product users were included in the final sample. Fifth, all  
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28 data were self-reported and subject to related biases. For instance, given that cannabis use is  
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30 illegal in North Carolina for adults and adolescents, it is possible that our prevalence estimate of  
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32 ever vaping cannabis is conservative. Finally, results can only be generalizable to adolescents in  
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34 a specific state (North Carolina).  
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### 37 38 **Conclusions**

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40 Findings suggest that adolescent cannabis vaping is an important public health issue that  
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42 is likely to affect and be affected by tobacco control and cannabis policies in states and at the  
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44 federal level in the US.<sup>29</sup> In North Carolina, three different bills were introduced to make it legal  
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46 for adults to possess medical cannabis in 2017.<sup>30-32</sup> While each of the bills were ultimately  
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48 defeated, our study among North Carolina high school students is relevant for subsequent  
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50 legislative initiatives in North Carolina. Increased research investigating how youth use e-  
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52 cigarette devices for other purposes beyond vaping nicotine, like the current study, is needed.  
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## Additional Information

**Author Contributions.** SDK designed the study, analyzed the data, and wrote the first draft of the manuscript. AOG, LMR, and JM obtained funding for the study. All authors (SDK, AO, CM, GAZ, LMR, JM, CH, AOG) contributed to the acquisition, analysis, or interpretation of the data, and revised the manuscript for important intellectual content. All authors (SDK, AO, CM, GAZ, LMR, JM, CH, AOG) read and approved the final manuscript. SDK attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. SDK is the guarantor.

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**Competing interests.** The authors have no competing interests to declare.

**Statement of Ethical Approval.** With regard to ethical approval, our study used secondary, de-identified data and did not constitute human subjects research as defined under federal

1  
2  
3 regulations 45 CFR 46.102 (d or f) and 21 CFR 56.102(c)(e)(1); hence, this study did not require  
4  
5 Institutional Review Board approval.  
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8 **Previous presentation of the information reported in the manuscript.** A poster presentation  
9  
10 of preliminary results was made at the Society for Research on Nicotine and Tobacco (SRNT)  
11  
12 annual meeting—February 2019.  
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15 **Data sharing.** Data will be made available upon request from Dr. Sarah Kowitt  
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17 (kowitt@unc.edu).  
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Table 1. Weighted participant characteristics stratified by ever vaping cannabis status, n=2,835, data collected from the 2017 North Carolina Youth Tobacco Survey

Variable	Total Sample, n=2,835 % (n)	Has never vaped cannabis, n=2,582 % (n)	Has ever vaped cannabis, n=253 % (n)	p-value
Ever used an e-cigarette to vape cannabis				
No	90.4% (2582)	--	--	
Yes	9.6% (253)	--	--	
Sex				
Female	51.2% (1428)	91.8% (1323)	8.2% (105)	p=0.04
Male	48.8% (1407)	89.0% (1259)	11.0% (148)	
Grade				
9 <sup>th</sup>	28.7% (904)	95.3% (856)	4.7% (48)	p<0.001
10 <sup>th</sup>	26.2% (696)	90.9% (638)	9.1% (58)	
11 <sup>th</sup>	24.0% (577)	89.4% (515)	10.6% (62)	
12 <sup>th</sup>	21.0% (658)	84.5% (573)	15.5% (85)	
Race				
Non-Hispanic White	52.8% (1503)	88.7% (1352)	11.3% (151)	p=0.02
Non-Hispanic Black	26.0% (650)	95.0% (617)	5.0% (33)	
Hispanic	14.1% (517)	89.5% (468)	10.5% (49)	
Non-Hispanic other	7.2% (167)	88.2% (145)	11.8% (20)	
Free or reduced-price lunch				
Yes	44.1% (1362)	90.1% (1249)	9.9% (113)	p=0.73
No	55.9% (1473)	90.7% (1333)	9.3% (140)	
Current cigarette use				
No	92.7% (2617)	92.2% (2436)	7.8% (181)	p<0.001
Yes	7.3% (218)	67.8% (146)	32.2% (72)	
Current cigar use				
No	88.9% (2497)	93.6% (2346)	6.4% (151)	p<0.001
Yes	11.1% (338)	65.2% (236)	34.8% (102)	
Current smokeless tobacco use				
No	94.3% (2649)	91.6% (2451)	8.4% (198)	p<0.001
Yes	5.7% (186)	71.7% (131)	28.3% (55)	
Current waterpipe use				
No	96.6% (2722)	91.6% (2516)	8.4% (206)	p<0.001
Yes	3.4% (113)	57.0% (66)	43.0% (47)	
Current tobacco e-cigarette use				
No	84.2% (2334)	94.2% (2217)	5.8% (117)	p<0.001
Yes	15.8% (501)	70.7% (365)	29.3% (136)	

Table 2. Weighted multivariable logistic regression results, <sup>a,b</sup> n=2,835, data collected from the 2017 North Carolina Youth Tobacco Survey

Variable	aOR (95% CI)
Male (ref. female)	1.33 (0.87, 2.04)
10 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>1.87 (1.01, 3.47)</b>
11 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>1.99 (1.21, 3.26)</b>
12 <sup>th</sup> grade (ref. 9 <sup>th</sup> grade)	<b>2.88 (1.46, 5.67)</b>
Black (ref. non-Hispanic White)	0.51 (0.22, 1.16)
Hispanic (ref. non-Hispanic White)	1.03 (0.78, 1.38)
Other race (ref. non-Hispanic White)	1.38 (0.72, 2.64)
Current cigarette use (ref. no current use)	1.27 (0.71, 2.29)
Current cigar use (ref. no current use)	<b>3.76 (2.33, 6.07)</b>
Current smokeless tobacco use (ref. no current use)	0.89 (0.42, 1.91)
Current waterpipe use (ref. no current use)	<b>2.32 (1.37, 3.93)</b>
Current tobacco e-cigarette use (ref. no current use)	<b>3.18 (2.38, 4.25)</b>
<sup>a</sup> Only variables that were statistically significant ( $p < 0.10$ ) in bivariate analyses were included in the multivariable model (i.e., sex, grade, race, current use of cigarettes, cigars, smokeless tobacco, waterpipe, or e-cigarettes, and ever use of e-cigarettes).	
<sup>b</sup> Boldface indicates significance $p < 0.05$	

## References

1. U.S. Department of Health and Human Services. E-Cigarette Use Among Youth and Young Adults: A Report of the Surgeon General. 2016. Available at: [https://e-cigarettes.surgeongeneral.gov/documents/2016\\_SGR\\_Full\\_Report\\_non-508.pdf](https://e-cigarettes.surgeongeneral.gov/documents/2016_SGR_Full_Report_non-508.pdf). Accessed August 15, 2017.
2. Budney AJ, Sargent JD, Lee DC. Vaping cannabis (marijuana): parallel concerns to e-cigs? *Addiction*. Nov 2015;110(11):1699-1704.
3. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. Monitoring the Future National Survey Results on Drug Use, 1975-2016: Key Findings on Adolescent Drug Use. Ann Arbor, MI: Institute for Social Research, The University of Michigan. 2017. Available at: <http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2016.pdf>. Accessed June 28, 2018.
4. Dai H, Hao J. Electronic cigarette and marijuana use among youth in the United States. *Addict Behav*. Mar 2017;66:48-54.
5. Dai H, Catley D, Richter KP, Goggin K, Ellerbeck EF. Electronic Cigarettes and Future Marijuana Use: A Longitudinal Study. *Pediatrics*. May 2018;141(5).
6. Schauer GL, King BA, Bunnell RE, Promoff G, McAfee TA. Toking, Vaping, and Eating for Health or Fun: Marijuana Use Patterns in Adults, U.S., 2014. *Am J Prev Med*. Jan 2016;50(1):1-8.
7. Lee DC, Crosier BS, Borodovsky JT, Sargent JD, Budney AJ. Online survey characterizing vaporizer use among cannabis users. *Drug Alcohol Depend*. Feb 1 2016;159:227-233.
8. Morean ME, Lipshie N, Josephson M, Foster D. Predictors of Adult E-Cigarette Users Vaporizing Cannabis Using E-Cigarettes and Vape-Pens. *Subst Use Misuse*. Jul 3 2017;52(8):974-981.
9. Morean ME, Kong G, Camenga DR, Cavallo DA, Krishnan-Sarin S. High School Students' Use of Electronic Cigarettes to Vaporize Cannabis. *Pediatrics*. Oct 2015;136(4):611-616.
10. Trivers KF, Phillips E, Gentzke AS, Tynan MA, Neff LJ. Prevalence of Cannabis Use in Electronic Cigarettes Among US Youth. *JAMA Pediatr*. Nov 1 2018;172(11):1097-1099.
11. Peters EN, Bae D, Barrington-Trimis JL, Jarvis BP, Leventhal AM. Prevalence and Sociodemographic Correlates of Adolescent Use and Polyuse of Combustible, Vaporized, and Edible Cannabis Products. *JAMA Network Open*. 2018;1(5):e182765-e182765.
12. U.S. Food and Drug Administration. Vaporizers, e-Cigarettes, and other electronic nicotine delivery systems (ENDS). 2017. Available at: <https://www.fda.gov/TobaccoProducts/Labeling/ProductsIngredientsComponents/ucm456610.htm#reporting>. Accessed 06/07/2017.
13. Public Health Law Center at Mitchell Hamline School of Law. U.S. E-Cigarette Regulations - 50 State Review (2016). 2016. Available at: <http://publichealthlawcenter.org/resources/us-e-cigarette-regulations-50-state-review>. Accessed August 4, 2016.
14. Centers for Disease Control and Prevention. National Youth Tobacco Survey (NYTS). 2016. Available at: [http://www.cdc.gov/tobacco/data\\_statistics/surveys/nyts/](http://www.cdc.gov/tobacco/data_statistics/surveys/nyts/). Accessed February 28, 2019.
15. Wang TW, Gentzke A, Sharapova S, Cullen KA, Ambrose BK, Jamal A. Tobacco Product Use Among Middle and High School Students - United States, 2011-2017. *MMWR Morb Mortal Wkly Rep*. Jun 8 2018;67(22):629-633.



16. Hall MG, Ribisl KM, Brewer NT. Smokers' and nonsmokers' beliefs about harmful tobacco constituents: implications for FDA communication efforts. *Nicotine Tob Res.* 2014;16(3):343-350.
17. Mammen G, Rehm J, Rueda S. Vaporizing cannabis through e-cigarettes: Prevalence and socio-demographic correlates among Ontario high school students. *Can J Public Health.* 2016;107(3):337-338.
18. Earleywine M, Barnwell SS. Decreased respiratory symptoms in cannabis users who vaporize. *Harm Reduct J.* Apr 16 2007;4:11.
19. Cox B. Can the research community respond adequately to the health risks of vaping? *Addiction.* Nov 2015;110(11):1708-1709.
20. Soneji SS, Sung HY, Primack BA, Pierce JP, Sargent JD. Quantifying population-level health benefits and harms of e-cigarette use in the United States. *PLoS One.* 2018;13(3):e0193328.
21. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, ME P. Monitoring the Future national survey results on drug use 1975-2018: Overview, key findings on adolescent drug use. 2019. Available at: <http://www.monitoringthefuture.org/pubs/monographs/mtf-overview2018.pdf>. Accessed February 4, 2019.
22. Campaign for Tobacco Free Kids. Electronic cigarettes should be included in smoke-free laws 2018. Available at: <https://www.tobaccofreekids.org/assets/factsheets/0387.pdf>. Accessed June 18, 2018.
23. Ghosh T, Van Dyke M, Maffey A, Whitley E, Gillim-Ross L, Wolk L. The public health framework of legalized marijuana in Colorado. *Am J Public Health.* 2016;106(1):21-27.
24. Garcia AD. City attorney: There's no reason Denver couldn't allow marijuana vaping. 2017. Available at: <https://denverite.com/2017/02/08/theres-no-reason-denver-couldnt-allow-marijuana-vaping/>. Accessed June 18, 2018.
25. U.S. Food and Drug Administration. The Real Cost Campaign. 2018. Available at: <https://www.fda.gov/tobaccoproducts/publichealtheducation/publiceducationcampaigns/therealcostcampaign/default.htm>. Accessed April 30, 2018.
26. Pacula RL, Kilmer B, Wagenaar AC, Chaloupka FJ, Caulkins JP. Developing public health regulations for marijuana: lessons from alcohol and tobacco. *Am J Public Health.* 2014;104(6):1021-1028.
27. Lopez G. Utah votes to legalize medical marijuana with Proposition 2. 2018. Available at: <https://www.vox.com/policy-and-politics/2018/11/7/18052950/utah-proposition-2-medical-marijuana-legalization-results>. Accessed February 4, 2019.
28. Campaign for Tobacco Free Kids. JUUL and Youth: Rising E-Cigarette Popularity. 2018. Available at: <https://www.tobaccofreekids.org/assets/factsheets/0394.pdf>. Accessed February 4, 2019.
29. Marijuana Policy Project. Medical Marijuana Bills Pending. 2018. Available at: <https://www.mpp.org/states/north-carolina/>. Accessed August 6, 2018.
30. North Carolina House Bill 185: Legalize Medical Marijuana. 2017. Available at: <https://www.ncleg.net/Sessions/2017/Bills/House/PDF/H185v1.pdf>. Accessed February 4, 2019.
31. North Carolina Senate Bill 648: Legalize Medical Marijuana. 2017. Available at: <https://www.ncleg.net/Sessions/2017/Bills/Senate/PDF/S648v1.pdf>. Accessed February 4, 2019.

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3 32. North Carolina Senate Bill 579: The Catherine A. Zanga Medical Marijuana Bill. 2017.  
4 Available at: <https://www.ncleg.net/Sessions/2017/Bills/Senate/PDF/S579v1.pdf>.  
5 Accessed February 4, 2019.  
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For peer review only

**Table A. Attrition analysis, n=3133, North Carolina Youth Tobacco Survey, 2017 <sup>a</sup>**

	Included in final sample, n=2835 (89.5%) n (%)	Not included in final sample, n=298 (10.5%) n (%)	P-value
Sex			
Female	1428 (94.1%)	91 (5.9%)	p<0.001
Male	1407 (85.5%)	201 (14.5)	
Grade			
9 <sup>th</sup>	904 (92.8%)	62 (7.2%)	p=0.15
10 <sup>th</sup>	696 (91.0%)	67 (9.0%)	
11 <sup>th</sup>	577 (89.9%)	64 (10.1%)	
12 <sup>th</sup>	658 (87.7%)	79 (12.4%)	
Race			
Non-Hispanic White	1503 (91.8%)	112 (8.2%)	p=0.006
Non-Hispanic Black	650 (89.1%)	74 (10.9%)	
Hispanic	517 (86.6%)	77 (13.4%)	
Non-Hispanic other race	165 (84.9%)	23 (15.1%)	
Free or reduced-price lunch			
Yes	1362 (88.6%)	146 (11.4%)	p=0.13
No	1473 (91.1%)	131 (8.9%)	
Current cigarette use			
No	2617 (93.3%)	167 (6.7%)	p<0.001
Yes	218 (75.5%)	48 (24.5%)	
Current cigar use			
No	2497 (93.1%)	151 (6.9%)	p<0.001
Yes	338 (80.0%)	75 (20.0%)	
Current smokeless tobacco use			
No	2649 (92.9%)	188 (7.1%)	p<0.001
Yes	186 (67.0%)	71 (33.0%)	
Current waterpipe use			
No	2722 (93.1%)	179 (6.9%)	p<0.001
Yes	113 (68.3%)	35 (31.7%)	
Current tobacco e-cigarette use			
No	2334 (92.7%)	156 (7.3%)	p=0.004
Yes	501 (85.9%)	74 (14.1%)	
<sup>a</sup> Percentages provided are row percentages, i.e., the percentage in the cell included in the first column and first row indicates that among females, 94.1% were included in the final sample.			

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	<b>Item No</b>	<b>Recommendation</b>	<b>Assessed</b>
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Yes, pg 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes, pg 2-3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes, pg 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes, pg 6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Yes, pg 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes, pg 6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Yes, pg 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes, pg 6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes, pg 6-7
Bias	9	Describe any efforts to address potential sources of bias	Yes, pg 7 (control variables)
Study size	10	Explain how the study size was arrived at	Yes, pg 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes, pg 6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Yes, pg 8
		(b) Describe any methods used to examine subgroups and interactions	N/A
		(c) Explain how missing data were addressed	Yes, pg 8
		(d) If applicable, describe analytical methods taking account of sampling strategy	No
		(e) Describe any sensitivity analyses	Yes, pg 13
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	No
		(b) Give reasons for non-participation at each stage	No
		(c) Consider use of a flow diagram	No

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes, pg 8-9
		(b) Indicate number of participants with missing data for each variable of interest	Yes, pg 13
Outcome data	15*	Report numbers of outcome events or summary measures	Yes, pg 8-9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Yes, pg 8-9 and Table 1 provided unadjusted estimates, but did not include their precision
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	Yes, pg 9-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes, pg 12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes, pg 13
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes, pg 13
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes, pg 14

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).