

## **Cannabis, vaping and respiratory symptoms in a probability sample of United States youth**

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Dr. Boyd conceptualized the study, drafted the initial manuscript, and revised the manuscript.  
Dr. McCabe critically reviewed and contributed to revisions of the manuscript.  
Dr. Evans-Polce critically reviewed and contributed to revisions of the manuscript.  
Dr. Veliz conceptualized the study, drafted the initial manuscript, conducted the data analytics, and contributed to the revisions of the manuscript.

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**Abbreviation list:**

AOR: adjusted odds ratio

CDC: Centers for Disease Control and Prevention

CI: confidence interval

ENDS: electronic nicotine delivery systems

EVALI: e-cigarette or vaping product use-associated lung injury

PATH: Population Assessment of Tobacco and Health (PATH) Study

# **Cannabis, vaping and respiratory symptoms in a probability sample of United States youth**

## **Abstract**

### **Purpose**

To explore the association between respiratory symptoms among US adolescents who were current (past-30-day) users of cigarettes, e-cigarettes, and/or cannabis, as well as lifetime users of cannabis with electronic nicotine delivery systems (ENDS).

### **Methods**

Wave 4 from a national probability sample (N = 14,798) of adolescents (12-17 years) using Population Assessment of Tobacco and Health Study data. Retention rate was 88.4%.

### **Results**

The odds of indicating “wheezing or whistling” in the chest were roughly two times higher among those who had used cannabis in ENDS (adjusted odds ratio [AOR] 1.81, 95% confidence interval [CI] 1.47-2.22); neither e-cigarettes nor cigarettes had a significant association with all five respiratory symptoms in the fully adjusted models.

### **Conclusions**

This study provides preliminary evidence that adolescents’ cannabis use with ENDS may have negative health consequences. Lifetime cannabis use with ENDS, was substantially associated with higher odds of respiratory symptoms.

### **Key words**

Adolescents, cannabis, cigarettes, e-cigarettes, electronic nicotine delivery systems (ENDS), Population Assessment of Tobacco and Health (PATH) Study, nicotine use, vaping

### **Implications and Contribution**

This study suggests that the inhalation of cannabis via vaping with ENDS is associated with pulmonary irritation among adolescents. As we learn more about the negative health consequences of vaping, we may discover that the respiratory symptoms identified here put youth at risk for future lung injury and infections.

## **Introduction**

The liquids most often vaped in electronic nicotine delivery systems (ENDS) contain water, flavors, solvents, and nicotine, although e-cigarette devices are often used to inhale cannabis [1,2]. Indeed, to ‘vape’ cannabis as wax, oil, hash oil, or cannabis plant material has increased over the past decade [3,4,5]. Recently, the Centers for Disease Control and Prevention (CDC) found that e-cigarette or vaping product use-associated lung injury, often referred to with the acronym EVALI [6], was predominately associated with cannabis products. According to the CDC, 84% of the cases were associated with cannabis-containing products, while 16% were exclusively nicotine-containing products [6].

To date, most of the studies that focused on adolescents e-cigarette use and associated respiratory symptoms did not assess cannabis vaping [7,8] although research suggests e-cigarette vapor is associated with lung damage in humans [9] as well as in animal study models [10]. Further, small clinical and record reviews have documented THC was often vaped [9,11,12] prior to symptoms. At this time, relatively little is known about the population level health consequences of adolescents’ use of ENDS, including using with cannabis and controlling for a history of asthma. To fill the knowledge gap, we investigated the association between respiratory symptoms among US adolescents who were current (past-30 day) users of cigarettes, e-cigarettes, and/or cannabis, as well as lifetime users of cannabis with ENDS.

## **Methods**

We used Wave 4 data from a national probability sample of adolescents from the Population Assessment of Tobacco and Health (PATH) Study (collected December/2016-January/2018)

[13]. The analytic sample included 14,798 respondents who completed Wave 4 of the youth survey of the PATH (See Table 1). Retention rate was 88.4% [13]. University of Michigan Human Subjects Review Board determined study exemption.

## **Measures**

The independent variables included past 30-day cigarette, e-cigarette, and cannabis use, as well as lifetime vaping of cannabis at Wave 4. Table 1 provides details on how these items were measured.

The major dependent measures for the analysis included the following self-reported symptoms during the past-year at Wave 4: (1) Wheezing or whistling in the chest; (2) Sleep disturbed due to wheezing; (3) Speech limited due to wheezing; (4) Sounded wheezy during or after exercise; and (5) Dry cough at night not associated with a cold or chest infection. Each symptom was treated as a binary variable (yes/no). Table 2 (see footnotes) provides details on how each symptom was measured along with prevalence rates.

## **Analyses**

Binary logistic regression models were fitted (both bivariate and adjusted models) to assess the association between the major independent and dependent variables: Past 30-day cigarette, e-cigarette, cannabis, and lifetime vaping of cannabis was used to predict self-reported respiratory symptoms among all respondents. The fully adjusted models controlled for key demographics (including diagnosis of asthma). Analyses used cross-sectional weights for Wave 4 (i.e., primary

sampling unit and stratum indicator for variance estimation) [14]. Sample sizes varied because listwise deletion was used for the analyses.

## **Results**

At Wave 4, 3.1% of respondents engaged in current use of cigarettes, 4.2% engaged in current use of e-cigarettes, and 4.7% engaged in current use of cannabis. Moreover, 8.9% of respondents indicated ever using cannabis in ENDS. One in five (17.6%) had a diagnosis of asthma at Wave 4.

Table 2 shows both odds ratios and adjusted odds ratios (measures of effect size). We found that respondents who had ever vaped cannabis had increased odds of indicating all five past-year respiratory symptoms in the fully adjusted models. Past 30-day use of cigarettes, e-cigarettes, and cannabis use were associated with some respiratory symptoms in bivariate analyses, but not in the adjusted models. (Additional sub-analyses assessing respondents with no history of asthma provided similar and consistent results. Tables can be provided upon request).

## **Discussion**

This study provides descriptive evidence that adolescents' cannabis vaping may have negative health consequences. Adolescents' current use of e-cigarettes or cigarettes was associated with several past-year respiratory symptoms in bivariate models (See Table 2); however, when controlling for vaping cannabis the symptoms were not statistically significant. Lifetime cannabis use with ENDS was associated with higher odds of all five past-year respiratory symptoms. Notably, the rates of cannabis use, in contrast to either e-cigarette or cigarette use,

revealed that many adolescents had vaped cannabis. Adkins et al. found that compared to adults, adolescents with EVALI had higher odds of having a history of asthma [15]. We also found a relationship; the associations of an asthma diagnosis and respiratory symptoms had greater magnitudes than either cigarette, e-cigarette, cannabis use, and vaping cannabis with ENDS.

There are several limitations related to secondary analysis within extant databases. For instance, some of the measures were not assessed in a similar manner at each wave of the PATH (i.e., lifetime vaping cannabis versus past 30-day cannabis use) making it more difficult to assess the longitudinal pattern based on current use. While this is a clear limitation, the current analyses of Wave 4 data captured the robust association between cannabis use with ENDS and respiratory symptoms during a critical stage of development among youth. As with all secondary data, there are limitations because of the type of data originally collected, including only lifetime cannabis use with ENDS. Another limitation is that co-use of cannabis and tobacco/nicotine was not assessed and, in the future, should be examined: researchers have found that co-use is related to EVALI symptoms among young adults [16]. Despite the limitations, to the best of our knowledge this is the first study to use Wave 4 PATH data—a time period that captured newer ENDS product use such as JUULs—to examine adolescents' use of ENDS and associated respiratory symptoms while accounting for asthma diagnoses. And finally, this exploratory study of Wave 4 PATH data points researchers in important directions. It appears the inhalation of cannabis via vaping is associated with some pulmonary irritation, and symptoms of lung diseases (both known and unknown). Indeed, the respiratory symptoms identified here may be a harbinger of later EVALI.



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**Table 1 Sample characteristics for PATH sample at Wave 4**

	N = 14,798	
	n	% mean (SE)
Sex <sup>a</sup>		
Male	7666	51.1 (0.005)
Female	7080	48.9 (0.005)
Race <sup>b</sup>		
White	9373	69.2 (0.013)
Black	2271	15.6 (0.010)
Other	2291	15.2 (0.007)
Hispanic ethnicity <sup>b</sup>		
Non-Hispanic	9899	76.2 (0.013)
Hispanic	4374	23.8 (0.013)
Age (Wave 4) <sup>c</sup>		
12 to 14 years	7337	49.7 (0.004)
15 to 17 years	7461	50.2 (0.004)
Household income <sup>d</sup>		
\$9,999 or lower	1227	761 (0.005)
\$10,000 to \$24,999	2262	14.2 (0.005)
\$25,000 to \$49,999	3306	21.9 (0.005)
\$50,000 to \$99,000	3665	26.8 (0.006)
\$100,000 or higher	3580	29.3 (0.011)
U.S. region <sup>e</sup>		
Northeast	2050	16.4 (0.008)
Midwest	3246	21.3 (0.012)
South	5617	38.3 (0.015)
West	3885	23.8 (0.014)
Lifetime asthma diagnosis <sup>f</sup>		
Parents indicated a diagnosis of asthma	2651	17.6 (0.004)
Past 30-day nicotine/tobacco/marijuana use <sup>g</sup>		
Past 30-day cigarette use (Wave 4)	459	3.1 (0.002)
Past 30-day e-cigarette use (Wave 4)	336	4.2 (0.002)
Past 30-day cannabis use (Wave 4)	577	4.7 (0.002)
Lifetime marijuana use (vaping) <sup>h</sup>		
Lifetime vaping cannabis (Wave 4)	1283	8.9 (0.003)

**Table 1 Sample characteristics for PATH sample at Wave 4**

Analyses used Stata version 15.0 (StataCorp LLC, College Station, Texas, USA).

Notes: N = Wave 4 of the PATH; n = unweighted sample size; percentages and standard errors (SE) incorporate longitudinal survey weights, stratum, and primary sampling unit.

Abbreviation: PATH, Population Assessment of Tobacco and Health (PATH) Study; SE, standard error.

<sup>a</sup> Sex was a derived variable from the interview and included “Male” or “Female” (i.e., PATH Study constructed the variable.)

<sup>b</sup> Race/ethnicity was a derived variable from the interview and included “White alone”, “Black alone”, or “Other”. Hispanic was derived from the interview and included either “Hispanic” or “Not Hispanic”.

<sup>c</sup> Age of respondent was a derived variable from the interview and included either “12 to 14 years old” or “15 to 17 years old”. No respondent “aged-out” of sample. At Wave 4, all respondents were  $\leq 17$  years.

<sup>d</sup> Household income was a derived variable from the interview and included five categories: “less than \$10,000”, “\$10,000 to \$24,999”, “\$25,000 to \$49,999”, “\$50,000 to \$99,999”, and “\$100,000 or more”. The income listed at Wave 4 was used for the analysis.

<sup>e</sup> Region was a derived variable from the interview.

<sup>f</sup> Lifetime asthma diagnosis was derived from parents’ responses in Waves 1 through 4 to the following questions: “Child has ever been told by a doctor or other health professional that he/she has asthma” [Asked at Wave 1 and Wave 4] and “In the past 12 months, has {child's first name} been told by a doctor, nurse or other health professional that {he/she} has asthma?” [Waves 1 through 4].

<sup>g</sup> Past 30-day cigarette, e-cigarette, and cannabis use was determined by asking respondents the following questions at Wave 4 “In the past 30 days, on how many days did you smoke cigarettes?” and “In the past 30 days, on how many days did you use an e-cigarette?” Past 30-day cannabis use was determined by asking respondents the following question at Wave 4 “Have you used marijuana, hash, THC, grass, pot or weed in the past 30 days?” Past-30-day cigarette, e-cigarette, and marijuana use were all coded as binary variables.

<sup>h</sup> Lifetime cannabis use (vaping) was assessed at Wave 4 by asking respondents the following: “Have you ever used marijuana, marijuana concentrates, marijuana waxes, THC, or hash oils in an e-cigarette or other electronic nicotine product such as an e-cigarette, vape, mod, personal vaporizer, e-hookah, or hookah pen?” The response options included “Yes” and “No”.

**Table 2 Characteristics of PATH youth respondents at Wave 4 and past-year respiratory symptoms**

Respiratory symptoms in the past year (Wave 4)	Wheezing or whistling in the chest <sup>a</sup>	Sleep disturbed due to wheezing <sup>b</sup>	Speech limited due to wheezing <sup>c</sup>	Sounded wheezy during or after exercise <sup>d</sup>	Dry cough at night not associated with a cold/chest infection <sup>e</sup>
Parents indicated a diagnosis of asthma (Wave 4)	(n = 14,557) OR (95% CI)	(n = 14,557) OR (95% CI)	(n = 14,557) OR (95% CI)	(n = 14,745) OR (95% CI)	(n = 14,745) OR (95% CI)
No	Reference	Reference	Reference	Reference	Reference
Yes	5.92*** (5.24, 6.68)	9.51*** (7.55, 11.9)	5.34*** (4.18, 6.83)	4.85*** (4.35, 5.41)	1.62*** (1.44, 1.82)
Past 30-day cigarette use (Wave 4)	(n = 14,289) OR (95% CI)	(n = 14,289) OR (95% CI)	(n = 14,289) OR (95% CI)	(n = 14,475) OR (95% CI)	(n = 14,475) OR (95% CI)
No	Reference	Reference	Reference	Reference	Reference
Yes	1.53*** (1.20, 1.94)	1.16 (.717, 1.88)	1.16 (.703, 1.94)	1.15 (.894, 1.48)	1.27* (1.01, 1.61)
Past 30-day e-cigarette use (Wave 4)	(n = 14,273) OR (95% CI)	(n = 14,273) OR (95% CI)	(n = 14,273) OR (95% CI)	(n = 14,453) OR (95% CI)	(n = 14,453) OR (95% CI)
No	Reference	Reference	Reference	Reference	Reference
Yes	1.34* (1.06, 1.69)	1.20 (.716, 2.01)	1.36 (.838, 2.22)	1.09 (.850, 1.40)	1.10 (.897, 1.34)
Past 30-day cannabis use (Wave 4)	(n = 14,559) OR (95% CI)	(n = 14,559) OR (95% CI)	(n = 14,559) OR (95% CI)	(n = 14,787) OR (95% CI)	(n = 14,787) OR (95% CI)
No	Reference	Reference	Reference	Reference	Reference
Yes	1.54*** (1.20, 1.97)	1.58* (1.07, 2.32)	1.54* (1.02, 2.32)	1.17 (.923, 1.49)	1.22* (1.00, 1.49)
Lifetime ENDS with cannabis (Wave 4)	(n = 13,679) OR (95% CI)	(n = 13,679) OR (95% CI)	(n = 13,679) OR (95% CI)	(n = 13,834) OR (95% CI)	(n = 13,834) OR (95% CI)
No	Reference	Reference	Reference	Reference	Reference
Yes	1.82*** (1.55, 2.13)	1.89*** (1.42, 2.53)	1.79*** (1.40, 2.31)	1.29*** (1.13, 1.47)	1.23** (1.06, 1.44)

Respiratory symptoms in the past year (Wave 4)	Wheezing or whistling in the chest <sup>a</sup>	Sleep disturbed due to wheezing <sup>b</sup>	Speech limited due to wheezing <sup>c</sup>	Sounded wheezy during or after exercise <sup>d</sup>	Dry cough at night not associated with a cold/chest infection <sup>e</sup>
Fully adjusted models	Model 1 (n = 12,595) AOR (95% CI)	Model 2 (n = 12,595) AOR (95% CI)	Model 3 (n = 12,595) AOR (95% CI)	Model 4 (n = 12,737) AOR (95% CI)	Model 5 (n = 12,737) AOR (95% CI)
Parents indicated a diagnosis of asthma (Wave 4)					
No	Reference	Reference	Reference	Reference	Reference
Yes	6.16*** (5.41, 7.03)	8.90*** (6.99, 11.3)	5.49*** (4.21, 7.17)	5.46*** (4.82, 6.18)	1.75*** (1.55, 1.98)
Past 30-day cigarette use (Wave 4)					
No	Reference	Reference	Reference	Reference	Reference
Yes	1.15 (.820, 1.62)	.739 (.405, 1.34)	.820 (.433, 1.55)	1.09 (.773, 1.54)	1.27 (.947, 1.71)
Past 30-day e-cigarette use (Wave 4)					
No	Reference	Reference	Reference	Reference	Reference
Yes	1.09 (.829, 1.44)	1.33 (.752, 2.36)	1.24 (.686, 2.25)	1.07 (.802, 1.44)	1.09 (.885, 1.36)
Past 30-day cannabis use (Wave 4)					
No	Reference	Reference	Reference	Reference	Reference
Yes	1.13 (.847, 1.52)	1.21 (.681, 2.18)	1.06 (.600, 1.89)	1.13 (.834, 1.54)	1.16 (.909, 1.49)
Lifetime ENDS with cannabis (Wave 4)					
No	Reference	Reference	Reference	Reference	Reference
Yes	1.81*** (1.47, 2.22)	1.71* (1.13, 2.58)	1.96*** (1.32, 2.90)	1.33** (1.10, 1.60)	1.26* (1.05, 1.51)

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**Table 2 Characteristics of PATH youth respondents at Wave 4 and past-year respiratory symptoms**

Notes: Unweighted samples sizes are provided. The cross-section of Wave 4 of the adolescent Population Assessment of Tobacco and Health (PATH) sample was used. Analyses used Stata version 15.0 (StataCorp LLC, College Station, Texas, USA). All analyses controlled for sex, race, Hispanic ethnicity, age, household income, and region (see Table 1 for more details).  $P < .05^*$ ,  $P < .01^{**}$ ,  $P < .001^{***}$   
Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; ENDS, electronic nicotine delivery systems.

<sup>a</sup> This item was measured with the following variable: “Have you had wheezing or whistling in the chest in the past 12 months?” Response categories were “Yes” and “No”. Past-year prevalence rates were the following: Wave 4 = 13.9% (0.004).

<sup>b</sup> This item was measured with the following variable: “In the past 12 months how often, on average, has your sleep been disturbed due to wheezing?” Response categories were “Never woken with wheezing”, “Less than one night per week”, and “One or more nights per week”. This item was recoded as a binary variable. Past-year prevalence rates were the following: Wave 4 = 2.9% (0.002).

<sup>c</sup> This item was measured with the following variable: “In the past 12 months, has wheezing ever been severe enough to limit your speech to only one or two words between breaths?” Response categories were “Yes” and “No”. Past-year prevalence rates were the following: Wave 4 = 2.9% (0.002).

<sup>d</sup> This item was measured with the following variable: “In the past 12 months, has your chest sounded wheezy during or after exercise?” Response categories were “Yes” and “No”. Past-year prevalence rates were the following: Wave 4 = 14.3% (0.003).

<sup>e</sup> This item was measured with the following variable: “A dry cough is a cough without phlegm or mucus. In the past 12 months, have you had a dry cough at night?” Response categories were “Yes” and “No”. Past-year prevalence rates for Wave 4 = 21.1% (0.004).