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E-cigarette Use Associated with Asthma Independent of Cigarette Smoking and Marijuana in a 2017 National Sample of Adolescents

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Abstract

Purpose: Knowledge about the health consequences of e-cigarette use in adolescence remains limited. Available studies of asthma among adolescents are based on data collected five or more years ago and evidence from more recent generations of e-cigarette products is needed.

Methods: We analyzed data from the 2017 Youth Risk Behavior Survey, a cross-sectional study with a representative US national sample of high school students. Multivariable analyses tested for associations of ever and 30-day e-cigarette use with asthma controlling for cigarette smoking, marijuana use, demographics, and obesity.

Results: A significant association with asthma was found for ever use of e-cigarettes, AOR = 1.15 (CI 1.02–1.30, $p = .02$) and for currently using e-cigarettes, AOR = 1.30 (CI 1.10–1.53, $p = .002$). Also related to asthma were current cigarette smoking, AOR = 1.24 (CI 1.03–1.51, $p = .03$) and obesity, AOR = 1.48 (CI 1.30–1.68, $p < .0001$). E-cigarettes had an additive effect for asthma beyond smoking ($p = .03$). Differentials in asthma prevalence by race/ethnicity were found, with lower prevalence of asthma for nonHispanic Asian ($p = .02$) and Hispanic ($p = .003$) and higher prevalence for nonHispanic black ($p < .0001$) and nonHispanic multi-race ($p < .0001$) relative to nonHispanic white populations.

Conclusions: E-cigarette use was significantly associated with asthma in recent data on adolescents, controlling for several disease-relevant covariates. The results are consistent with studies based on older generations of e-cigarettes and support the significance of e-cigarettes as a continuing public health concern.

Introduction

The increasing prevalence of use of electronic nicotine delivery devices (hereafter, e-cigarettes) in the US in recent years [1,2] has raised several types of concerns. In addition to

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the implications of e-cigarettes for initiation of cigarette smoking [3,4] there is concern about the possibility of creating nicotine dependence in a new generation of youth [5–7]. These issues together with case reports of respiratory distress linked to e-cigarette use [8–10] have raised concern about e-cigarettes among a broad range of health professionals [11–13]. However, there remains limited knowledge about the health implications of e-cigarette use for adolescents [14]. The present research was conducted to address this issue.

There has been some previous research about e-cigarette use and asthma in adolescence. Cho and Paik [15] reported analyses of data collected in 2014 from a sample of Korean high school students and noted a significant association of e-cigarette use with reports of being diagnosed with asthma by a doctor and being absent from school because of asthma. In the first US paper, Choi and Bernat [16] analyzed data from a 2012 statewide survey of Florida high schools and reported that e-cigarette use was associated with asthma in the general population of high school students and was associated with more past-year asthma exacerbations among youth who had asthma. Schweitzer et al. [17] conducted related analyses with data from a 2015 statewide survey of high school students in Hawaii and reported that e-cigarette use was significantly associated with both previously having and currently having asthma. Thus there is some evidence of an association between e-cigarette use and asthma and this is conceptually consistent with basic research on respiratory effects for e-cigarette vapor and flavoring constituents [18].

However, the available evidence on respiratory variables is based on data from early generations of e-cigarette products when there have been substantial changes in these products over time. E-cigarette devices are now customizable, a wide variety of flavorings are available, and nicotine levels are higher than in first-generation devices [1]. Thus there is a need for research based on more recent data. Additionally there is a need for analyses that control not only for cigarette smoking, a major risk factor for respiratory disease, but also for other variables linked to respiratory disorder such as marijuana use [19] and obesity [20].

The present research analyzes data from a 2017 national survey of US adolescents. We investigate the association of e-cigarette use with asthma and address questions that have not been clarified in previous studies. One question is whether observed effects for e-cigarettes might be confounded with marijuana use, which is prevalent among US adolescents [19] and also may be related to respiratory disorder. We address this through testing for independent associations of e-cigarettes, combustible cigarettes, and marijuana in relation to adolescent asthma. Another question is whether the common pattern of dual use (i.e., smoking and using e-cigarettes) carries increased absolute risk above and beyond the effect of cigarette smoking. We investigate these questions with multivariable analyses that control for a number of disease-relevant covariates, and we consider absolute as well as relative risk through comparing asthma rates for dual users with those for exclusive e-cigarette users and exclusive smokers.

Methods

The 2017 Youth Risk Behavior Survey (YRBS) used a three-stage design to produce a representative sample of 9th through 12th grade students in public and private schools in the

United States. Of 192 schools selected, there was a 75% school response rate and an 81% student response rate. A 99-item questionnaire was administered to students in classrooms by trained research staff using a standardized protocol. Consent procedures varied across school districts, with some using signed parental consent and some using altered consent procedures. In the classroom, data collectors distributed the surveys and read standardized instructions to participating students. Survey administration and coding procedures were designed to emphasize student privacy through voluntary and anonymous participation. Local procedures were used to allow students who were absent on the initial day of data collection to complete the survey later, which increases completion rates and representativeness of the data. A total of 14,765 usable questionnaires were obtained. The present research uses anonymized data obtained from the US Centers for Disease Control (CDC) and was approved by the Institutional Review Board of the University of Hawaii at Manoa.

Measures

Demographics.

Initial items asked about age in years (7 responses, 12 through 18 years) and gender (dichotomous). Items about ethnicity (“Are you Hispanic or Latino?” Yes/No) and race (“What is your race?” 5 options, multiple responding allowed) were combined in an 8-category measure termed Race/Ethnicity.

Body mass index.

Questions about height (“How tall are you without your shoes on?”) and weight (“How much do you weigh without your shoes on?”) were combined for a standard measure of body mass index. This was coded by CDC to produce mutually exclusive dichotomous scores for Overweight (overweight vs. normal weight) and Obesity (obese vs. normal weight).

E-cigarette use.

Items followed the lead-in instruction: “The next questions ask about electronic vapor products, such as blu, NJOY, Vuse, MarkTen, Logic, Vapin Plus, eGo, and Halo. Electronic vapor products include e-cigarettes, e-cigars, e-pipes, vape pipes, vaping pens, e-hookahs, and hookah pens.” Items were included for e-cigarette ever use (“Have you ever used an electronic vapor product?” Yes/No) and current use (“During the past 30 days, on how many days did you use an electronic vapor product?” 7 responses, 0 days to All 30 Days).

Cigarette smoking.

Items were included for ever smoking (“Have you ever tried cigarette smoking, even one or two puffs?” Yes/No) and current smoking (“During the past 30 days, in how many days did you smoke cigarettes?” 7 responses, 0 days to All 30 Days).

Marijuana.

Items for marijuana tapped lifetime use ("During your life, how many times have you used marijuana?" 7 responses, 0 times to 100 or more times) and current use ("During the past 30 days, how many times did you use marijuana?" 6 responses, 0 times to 40 or more times).

Asthma.

The item for asthma status asked about being diagnosed by a health professional ("Has a doctor or nurse ever told you that you have asthma?" Yes/No).

Analysis Methods

Analyses were conducted with SAS version 9.3. Items were recoded for analysis such that a higher score meant more of the named quantity (e.g., e-cigarette use). Prevalence rates for the study variables were determined with Proc SurveyFreq using survey weights and adjustment for stratum and school clustering. Two small groups were dropped from age (12 years and 13 years) and from race-ethnicity (American Indian/Alaska Native and Native Hawaiian/Pacific Islander) because of small cell sizes. Race/ethnicity was coded with five dummy variables that contrasted nonHispanic Asians, nonHispanic blacks, Hispanics, Hispanic multi-race, and nonHispanic multi-race against nonHispanic whites as the reference group. Cross-tabulation analyses examined the association of asthma status with other variables and the correlation of e-cigarettes with cigarettes and marijuana. Four categories of tobacco product usage were constructed based on e-cigarette and cigarette use, producing groups for Exclusive E-cigarette Use, Exclusive Cigarette Smoking, Dual User (E-cigarettes + Cigarettes), and Neither; groupings were constructed both for ever-use indices and for current (any past-30-day use) indices. Multivariable analysis was performed in logistic regression with asthma as the criterion. Entered simultaneously to the model were demographics (age, gender, race/ethnicity), overweight status, obesity status, e-cigarette use, cigarette smoking, and marijuana use (ever or any past-30-day use). Analyses were performed for relative risk using scores for e-cigarettes, smoking, and marijuana entered together. To test for interaction we added the cross-product of e-cigarettes and cigarette smoking (ever or current) or the cross-product of e-cigarettes and marijuana (ever or current) to the regression models in addition to their main effects and the covariates. We analyzed absolute risk using dummy variables for tobacco product group status (three dichotomous indices contrasting Exclusive E-cigarette Users, Exclusive Cigarette Smokers, and Dual Users against Neither as the reference group) entered in multivariable analysis with asthma as the criterion. The additive effect of e-cigarette use over smoking was tested with a different contrast, which compared asthma prevalence for Dual Users vs. Exclusive Smokers. These analyses were based on listwise deletion but a sensitivity analysis tested this effect in a sample with complete data.

Results

Prevalence of study variables was estimated for the analytic sample, defined as nonmissing on e-cigarettes, cigarettes, marijuana, and asthma (Table 1). (Prevalence for these variables in the analytic sample was identical to those in the full sample.) Weighted sample sizes

ranged from N = 11,428 (overweight and obesity) to 12,672 (e-cigarette ever use). The sample was 51% female and mean age was 16.0 years (SD 1.2). The largest ethnic group was nonHispanic whites (57%) followed by nonHispanic blacks (12%) and Hispanics (10%). NonHispanic Asians were the smallest single group (4%) but multiple memberships were common, with 12% prevalence for multi-race including Hispanic ethnicity and 4% for multi-race including other race/ethnicity (5%). Based on the CDC criteria, 16% of this sample were overweight and 15% qualified as obese. E-cigarette use (ever-use prevalence 42%) was more common than cigarette smoking (29%), with marijuana use intermediate (36%). Prevalence rates for 30-day use were lower: 13%, 9%, and 20%, respectively. The lifetime prevalence of asthma was indicated as 23%.

Cross-tabulation analyses indicated current e-cigarette use had a positive univariate association with asthma, Rao-Scott χ^2 (1 df) = 14.32, p = .0001, as did cigarette smoking, χ^2 (1 df) = 8.80, p = .003, and marijuana use, χ^2 (1 df) = 27.87, p < .0001. (Results were similar for ever use.) In terms of ever-use groupings, 19% of the sample were Exclusive E-cigarette Users, 6% were Exclusive Cigarette Smokers, 23% were Dual Users, and 52% of the sample were Nonusers (Table 2A). For current use, 6% were Exclusive E-cigarette Users, 3% Exclusive Cigarette Smokers, 7% Dual Users, and 85% had not used either tobacco product in the past 30 days (Table 2B).

Cross-tabulation with asthma status indicated stronger association for current-use groupings (Table 2B): The prevalence of asthma was 23% among Nonusers but was 29% for Exclusive E-cigarette Users and was 31% for Dual Users, Rao-Scott χ^2 (3 df) = 19.23, p = .0002. For grouping based on ever use (Table 2A), the association was still significant, χ^2 (3 df) = 11.04, p = .01. Marijuana use was correlated with the groupings. For example for current use, the prevalence for marijuana was 9% among the nonuser group but was 50% among exclusive e-cigarette users, 59% among exclusive smokers, and 71% among dual users. (The proportions were similar for ever use.) Thus marijuana was included as a covariate in multivariable analyses.

Other study variables were also related to asthma status. For weight status, 27% of participants who were overweight had asthma compared to 24% for non-overweight (Rao-Scott χ^2 (1 df) = 11.19, p = .001); for obesity the proportions were 30% and 23% respectively, χ^2 (1 df) = 19.35, p < .0001. For race/ethnicity compared to the population rate of 24%, significantly lower prevalence was noted among Asian Americans (15%) and Hispanics (19%), and significantly higher prevalence was noted among Blacks (30%) and multiple-race NonHispanics (34%). Whites at 23% were close to the population rate, and overall χ^2 (5 df) was 133.01, p < .0001. In the univariate analysis, asthma was more prevalent among ever marijuana users (27%) and current marijuana users (28%) vs. base rates of 22% and 23%, respectively. Gender and age did not show significant associations with asthma in this sample.

Analysis for Independent Effects

In logistic regression with asthma as the criterion, the univariate odds ratios based on ever-use indices were 1.19 (95% Confidence Interval [CI] 1.08–1.31, p = .0005) for cigarette

smoking, 1.29 (CI 1.19–140, p < .0001) for marijuana use, and 1.29 (CI 1.19–1.40, p < .0001) for e-cigarette use For dichotomous current-use indices the respective univariate odds ratios were 1.59 (CI 1.38–1.82, p < .0001) for cigarette smoking, 1.32 (CI 1.19–1.45, p < .0001) for marijuana, and 1.47 (CI 1.31–1.66, p < .0001) for e-cigarettes. In multivariable models involving simultaneous entry of these three variables with all covariates (Table 3) some of the associations remained significant and some did not. In the model for current use there were two independent effects: the adjusted odds ratio (AOR) for e-cigarettes was 1.30 (CI 1.10–1.53, p = .001) and the AOR for cigarette smoking was 1.24 (CI 1.03–1.51, p = .03); marijuana was not significant in the full model. For the ever use indices, e-cigarette use was the only significant unique predictor, AOR = 1.15 (CI 1.02–1.30, p = .02). We note that these results are based on dichotomous predictors but when scaled scores for frequency of current e-cigarette, cigarette, and marijuana were entered in the model the results were similar (data not shown).

Consistent with the univariate analyses, the multivariable model showed overweight and obese status had positive associations with asthma. Inverse odds ratios (i.e., lower prevalence of asthma relative to nonHispanic White) were noted for nonHispanic Asians and Hispanics, and positive odds ratios (i.e., higher prevalence relative to nonHispanic whites) were found for nonHispanic Blacks and Nonhispanic multi-race populations.

We tested for interaction by adding cross-products of e-cigarettes and smoking, and cross-products of e-cigarettes with marijuana, to the variables in the model in Table 3, doing this for both ever-use indices and current-use indices. There was no consistent evidence of interaction effects. We conclude that while e-cigarettes and cigarettes have independent effects, the magnitude of the association of e-cigarettes with asthma does not vary significantly according to cigarette smoking or marijuana use.

Analysis for Additive Effects

We tested the association of asthma with the tobacco product groups, including marijuana and all the covariates in the previous analyses. Again, analyses were conducted for groupings based on ever use and on current use. Results (Table 4) showed that the prevalence of asthma was significantly elevated for Exclusive E-cigarette Users compared with Nonusers (for current use, AOR = 1.29 (CI 1.07–1.55, p = .01). There was also a strong elevation for Dual Users compared with Nonusers, AOR= 1.62 (CI 1.32–1.99, p < .0001).

The additive effect of e-cigarettes above and beyond cigarette smoking was tested using a different contrast, which coded Exclusive Cigarette Smokers as the reference group. In this approach, the contrast of Dual Users vs. Exclusive Cigarette Smokers represents the additive effect of e-cigarette use for asthma above and beyond that of smoking. For grouping based on ever use indices, this analysis was not significant; this is consistent with the minimal increase in absolute risk indicated in Table 2A. For grouping based on current-use indices, the contrast for Exclusive E-cigarette Users vs. Exclusive Cigarette Smokers was nonsignificant, AOR = 1.06 (CI 0.76–1.46) indicating that this group did not differ from smokers in their risk for asthma. The contrast of Dual Users with Exclusive Cigarette Smokers was not significant, AOR = 1.32 (CI 0.95–1.84, p = .10). This is consistent with the

elevation in risk for dual users indicated in Table 2B. The sensitivity analysis tested this question in a sample with complete data (Supplementary Table 1) and found the additive effect was significant (p = .03). This analysis indicates there is an increment in absolute risk attributable to e-cigarette use above and beyond that for smoking.

Discussion

The aim of this research was to investigate how e-cigarette use is associated with asthma for a more recent generation of electronic cigarette devices. The data were from a representative national sample of adolescents and the criterion was being diagnosed with asthma by a health professional. Multivariable analyses included a number of covariates that were themselves significant predictors of asthma. We used analytic approaches that focused on the relative risk for asthma among e-cigarette users and on the absolute risk for asthma associated with e-cigarette use, either alone or in combination with cigarette smoking. Both types of analyses supported the conclusion that although asthma has multiple causes, e-cigarette use was associated with asthma independent of cigarette smoking and marijuana use and had an additive effect above and beyond that of cigarette smoking.

The present research is based on data collected in 2017, when electronic nicotine delivery devices had changed considerably in comparison to the simple pen-like devices used in the first generation of e-cigarettes. Still, the results we observed are not greatly dissimilar from those in previous studies [15–17]. Supporting these previous studies, we found stronger results for current e-cigarette use in comparison to ever-use indices. Also as in previous studies we noted that cigarette smoking and marijuana use were both significantly correlated with e-cigarette use, an important potential confound that we dealt with in multivariable analyses. We found that in the multivariable analyses, cigarette smoking and marijuana use sometimes did not have significant unique associations with asthma and e-cigarette use was the main predictor [cf.18]. It is also worth noting that in cases where cigarette smoking was significant, the effect size for e-cigarettes was comparable to that for smoking (e.g., AORs of 1.30 vs. 1.24, Table 3 right column) and for other recognized risk factors for asthma such as obesity.

The present results are also consistent with previous findings for the covariates. Overweight and obesity were significantly associated with asthma, consistent with previous epidemiological data [15,17, 20]. A number of effects for race/ethnicity were also observed. NonHispanic Asians and Hispanics were both underrepresented (relative to nonHispanic Whites) among youth with asthma, whereas nonHispanic blacks and nonHispanic persons with multiple races were overrepresented. The present research was not designed to explore the reason for these differences but our results do serve to work against several possible explanations for the race/ethnicity results because the observed effects were independent of obesity and substance use. This serves to make investigation of other explanations for racial/ethnic differences (e.g., differential environmental exposures) more plausible. Of course differences in obesity, e-cigarette use, and cigarette smoking could account for part of the ethnic differentials, and this should be explored in further research.

The question of how e-cigarette use may be related to respiratory disorder is a central issue for current research. Theoretical papers have pointed out possible directions based on evidence from controlled laboratory research [18, 22]. For example, studies have shown e-cigarette vapor to have cytotoxic effects, killing lung cells and causing DNA damage in various cell lines [23–26]. Heating e-cigarette liquid has been linked to the production of reactive oxygen species, causing oxidative stress that degrades the functioning of lung systems [27–30]. Exposure to e-cigarette vapor also affects immune system functioning and brings about genetic changes that may increase susceptibility to infection [31–34]. Testing whether these processes are involved in human clinical and epidemiological studies is a promising direction for further research.

Limitations.

Although the present study used a large representative sample and controlled for a number of disease-relevant covariates, some aspects could be noted as limitations. The standard national YRBS survey did not include an item on currently having asthma, which previous research has been shown to have stronger linkages with e-cigarette use [17]; thus the present results may represent an underestimate of effects. The survey did not ask about the type of e-cigarette device used and did not collect data on second-hand smoke exposure and household conditions [21,35]; such information needs to be included in further research. The study was cross-sectional and the association of e-cigarette use with asthma in cross-sectional data has sometimes been interpreted as showing the persons quit smoking and take up e-cigarette use when they develop respiratory disease (i.e., reverse causation argument). However, several studies have shown that associations of e-cigarette use with respiratory disease occur primarily among nonsmokers [17,21,36] hence reverse causation is not a plausible explanation for the results, and a prospective study with adults has shown e-cigarette use to precede onset of respiratory disease [37]. Finally, because the YRBS items do not mention JUUL devices, it is possible that the e-cigarette group is missing some youth who used JUUL but did not consider JUUL to be an e-cigarette.

Conclusions

The present research confirms results of previous studies showing associations of e-cigarette use with asthma in samples of adolescents. Our analyses controlled for both cigarette smoking and marijuana use, which strengthens the conclusion of a nonspurious association, and the effect sizes (AORs of 1.30 – 1.60) are significant from a public health standpoint given the prevalence of e-cigarette use among adolescents. While recent reports of pulmonary injury related to vaping marijuana have documented a clinically significant problem [38,39], the present results on e-cigarettes and asthma are consistent with previous epidemiology studies and case reports going back eight years [8–10,16], which demonstrates that adverse respiratory effects have been occurring for some time. Also there is now converging evidence from epidemiological and laboratory studies to rule out several alternative explanations for the association [18,40]. While there are multiple environmental and individual factors that contribute to asthma, we conclude that e-cigarettes represent a significant public health concern. Efforts are needed to educate youth about risks,

specifically study vaping of marijuana, and institute regulations to reduce the prevalence of e-cigarette use among adolescents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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IMPLICATIONS AND CONTRIBUTION

Data from a representative sample of US adolescents show e-cigarette use is associated with a higher likelihood of having asthma, above and beyond several other variables that create risk for respiratory disease. This indicates that e-cigarettes are a continuing concern for adolescents using recent generations of electronic nicotine delivery devices.

Table 1.

Sample characteristics, 2017 Youth Risk Behavior Survey (YRBS).

Characteristic	Categories	Unweighted N	Weighted %
Gender	Female	7428	51
	Male	7224	49
	Missing	127	
Age (years)	14	1711	12
	15	3665	25
	16	3727	26
	17	3555	24
	18	1961	13
	Missing	162	
Overweight	No	11107	84
	Yes	2057	16
	Missing	1619	
Obese	No	11218	85
	Yes	1946	15
	Missing	1619	
Race/ethnicity	Non-Hispanic Asian	505	4
	Non-Hispanic black	1940	14
	Non-Hispanic white	7736	54
	Hispanic	1415	10
	Hispanic multi-race	1889	13
	Non-Hispanic multi-race	799	6
	Missing	590	
Ever e-cigarette use	No	8171	58
	Yes	5973	42
	Missing	452	
Past-30-day e-cigarette use	No	10900	87
	Yes	1659	13
	Missing	1921	
Ever cigarette use	No	9851	71
	Yes	4009	29
	Missing	2853	
Past-30-day cigarette use	No	13129	91
	Yes	1269	9
	Missing	358	
Ever marijuana use	No	9310	64
	Yes	5139	36
	Missing	483	
Past-30-day marijuana use	No	11632	80
	Yes	3251	20

Characteristic	Categories	Unweighted N	Weighted %
	Missing	379	
Ever told having asthma	No	10330	76
	Yes	3176	24
	Missing	1524	

Table 2.

Joint distributions of e-cigarette use, cigarette use, and asthma.

	Asthma		
	No [N(weighted %)]	**Yes [N(weighted %)]**	**Marginal [N(weighted %)]**
(A) Ever user of…			
E-cigarettes only	1712 (75%)	572 (25%) *	2284 (19%)
Cigarettes only	540 (77%)	158 (23%)	699 (6%)
Both products	2148 (74%) **	736 (26%) ****	2884 (23%)
Neither products	5051 (78%)	1394 (22%) *	6445 (52%)
(B) Past-30-day user of…			
E-cigarettes only	517 (71%)	206 (29%) *	723 (6%)
Cigarettes only	242 (76%)	76 (24%)	318 (3%)
Both products	593 (69%) **	230 (31%) ****	733 (7%)
Neither products	7394 (77%)	2166 (23%)	9560 (84%)

Note: Weighted analysis, controlling for stratum and clustering. Significance tests based on cell chi-square with 1df.

* $p < .05$

** $p < .01$

**** $p < .0001$

Table 3.

Associations of Ever and Past-30-day E-cigarette Use, Cigarette Smoking, Marijuana Use, and Covariates with Asthma in Multiple Logistic Regression

	Model A: Ever use			Model B: Past-30-day use		
Variables	**AOR**	**95% CI**	**p**	**AOR**	**95% CI**	**p**
E-cigarettes (ref. No)	1.15	1.02–1.30	0.02	1.30	1.10–1.53	0.002
Cigarettes (ref. No)	0.99	0.87–1.12	0.83	1.24	1.03–1.51	0.03
Marijuana (ref. No)	1.12	0.99–1.27	0.07	1.08	0.95–1.24	0.25
Covariates						
Gender (ref: Female)	1.02	0.92–1.12	0.72	1.01	0.92–1.11	0.86
Overweight (ref: No)	1.23	1.08–1.40	0.002	1.25	1.10–1.42	0.0005
Obese (ref: No)	1.52	1.34–1.74	<0.0001	1.48	1.30–1.68	<0.0001
Age	0.99	0.95–1.03	0.52	1.00	0.96–1.04	0.87
NH Asian (ref NH white)	0.67	0.51–0.88	0.005	0.73	0.57–0.94	0.02
NH black (ref. NH white)	1.44	1.25–1.65	<0.0001	1.45	1.28–1.64	<0.0001
Hispanic (ref NH white)	0.76	0.64–0.90	0.002	0.76	0.63–0.91	0.03
Hispanic multi-race (ref NH white)	1.06	0.92–1.23	0.40	1.13	0.98–1.30	0.09
NH multi-race (ref. NH white)	1.75	1.44–2.12	<0.0001	1.84	1.53–2.22	<0.0001

Note: All variables entered in model simultaneously. NH = NonHispanic. E-cigarettes, smoking and marijuana are binary (0,1) variables based on ever use (Model A) or use in past 30 days (Model B).

Table 4.

Associations of Ever and Past-30-day Joint Distribution of E-cigarette and Cigarette Use, Marijuana Use, and Covariates with Asthma in Multiple Logistic Regression

	Model A: Ever use			Model B: Past-30-day use		
Variables	**AOR**	**95% CI**	**p**	**AOR**	**95% CI**	**p**
E-cigarettes only	1.16	1.01–1.33	0.04	1.29	1.07–1.55	0.01
Cigarettes only	1.01	0.81–1.25	0.96	1.23	0.92–1.64	0.17
Both e-cigarettes and cigarettes	1.13	0.97–1.31	0.11	1.62	1.32–1.99	<0.0001
Marijuana	1.12	0.99–1.27	0.07	1.08	0.94–1.24	0.25
Covariates						
Gender (ref.: Female)	1.02	0.92–1.12	0.72	1.01	0.92–1.11	0.86
Overweight (ref.: No)	1.23	1.08–1.40	0.002	1.25	1.10–1.42	0.0005
Obese (ref.: No)	1.52	1.34–1.74	<0.0001	1.48	1.30–1.68	<0.0001
Age	0.99	0.95–1.03	0.52	1.00	0.96–1.04	0.88
NH Asian (ref. NH white)	0.67	10.51–0.85	0.005	0.73	0.56–0.94	0.02
NH black (ref. NH white)	1.45	1.25–1.65	<0.0001	1.45	1.28–1.64	<0.0001
Hispanic (ref. NH white)	0.76	0.64–0.91	0.02	0.76	0.63–0.91	0.01
Hispanic multi-race (ref. NH white)	1.06	0.92–1.23	0.40	1.13	0.98–1.30	0.09
NH multi-race (ref. NH white)	1.75	1.44–2.11	<0.0001	1.84	1.53–2.22	<0.0001

Note: NH: Non-Hispanic. All variables entered in model simultaneously. Indices for tobacco product groups are binary (0,1) variables based on ever use (Model A) or use in past 30 days (Model B); reference group = didn't use either.