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Electronic Cigarettes and their Effects on Developing Symptoms of Respiratory Diseases among the Youth

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Abstract

Background: Electronic Cigarettes (EC) are new and popular harm reduction devices that are used to help current smokers quit smoking traditional cigarettes (TC). Although many public health practitioners would agree that this harm reduction strategy will be beneficial to the population, others would argue that it could be a gateway to smoking cigarettes for non-smokers, and young adults to start using EC. EC are not classified as combustible devices, but they still have some potential risks that can affect one's health. The purpose of this study is to analyze the use of EC and determine if there is a relationship between their use and the development of symptoms of respiratory diseases within the youth population.

Methods: The Population Assessment of Tobacco Health (PATH) data set was used to analyze, this research question. Wheezing, shortness of breath and dry cough are the three-main outcome of interest. Types of tobacco products and frequency of tobacco product use are the two main exposers of interest. A logistic regression analysis was conducted to test for the association between all exposures with all outcomes of interest while adjusting for other variables.

Results: Current EC users had an odds ratio of 1.10 (95% CI 0.71; 1.72) of experiencing shortness of breath compared to non-users while adjusting for all covariates. Current EC users had an odds ratio of 0.92 (95% CI 0.72; 1.17) of experiencing wheezing compared to non-users while adjusting for all covariates. Current EC users had an odds ratio of 1.01 (95% CI 0.79; 1.28) of experiencing dry cough compared to non-users while adjusting for all covariates.

Conclusion: EC's are a new product that many people in the youth population have not used during the time that the survey was conducted. This resulted in a small sample size of EC use. Due to these factors, there was no statistically significant relationship at the 0.05 p-value level between any EC and symptoms of respiratory disease.

Keywords: Respiratory Diseases • Tobacco • Smoking • Electronic Cigarettes • Chronic Bronchitis

Introduction

Electronic cigarettes (EC) are a new, controversial type of product that has left public health practitioners in a constant debate on its risk has on the population versus its benefits. EC are non-combustible devices that are used to deliver aerosolized nicotine [1]. The aerosol is generated by heating liquid within the cartridges for the user to inhale. The process of inhaling the vapor from EC can allow the users to feel the same sensation of smoking traditional cigarettes (TC) [2,3]. EC purpose is to be used as a harm reduction device and help TC smokers quit [4].

Harm reduction strategies are necessary because they help reduce risk of diseases and poor health outcomes that are created by TC. Since EC were placed in the market, the popularity for them has increased dramatically. They are also one of the most searched for alternative tobacco devices on Google within the United States, Australia, United Kingdom, and Canada [1]. With the increasing popularity of EC, studies have shown that 24% of adults and 15% of youth aged 12-17 reported using EC with TC simultaneously [5]. The benefit of using EC is that it can be an excellent substitute for heavy users of TC [6]. Switching to EC can reduce cravings and improve the overall quality of life of former smokers [7]. Although EC are a harm reduction strategy used to decrease the prevalence of smoking, many would argue that it can be a gateway for non-smokers to start using EC [2,3]. The vapor in EC can contain chemicals that can be harmful, such as diacetyl and formaldehyde.

Diacetyl is commonly found in some flavored EC, and prolonged exposure can cause bronchiolitis obliterans, also known as popcorn lung [7]. Popcorn lung is inflammation of the bronchi that can cause scarring in the lung tissue over time [7]. Popcorn Lung has similar symptoms as Chronic Obstructive Pulmonary Disorder (COPD) and can often be misdiagnosed by physicians [7]. EC aerosols that are heated excessively contain formaldehyde above the United States Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) [8]. It is a known eye, skin, and respiratory tract irritant and has been classified as a human carcinogen [9,10]. Formaldehyde levels have been known to be much higher in some EC than TC [11].

Chronic bronchitis is another example of a lung disorder that can be influenced by EC [12]. It causes inflammation of the bronchi that result in an increase in mucus production. Adolescent users of EC have been known to have a high risk of developing symptoms of chronic bronchitis [12]. Long-term use of EC has the potential of causing some respiratory illness. To be diagnosed with a respiratory disorder, reoccurring symptoms such as an increase in mucus production, chronic coughs, frequent reoccurring bronchitis, and occasional wheezing must be present [12].

Due to all the harm reduction strategies that have been in place, there has been an overall decrease in TC use within the past 50 years. However, there has been an increase in EC use across all age groups [13]. Although evidence suggests EC are more beneficial to current TC smokers who want to quit using [4], advertisements for EC are more likely to target non-smokers in the youth population [14]. Advertisements associate EC with happiness, friendship, sex,

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and success which are appealing to the youth population [15]. Non-smokers who start using EC at a younger age might be more likely to try other tobacco products when they get older. Over 90% of current tobacco users admit to using tobacco before the age of 18.13 EC has a classic tech-savvy design that makes it portable and easy to use. The design of the EC and their association with animation characters are known to attract the attention of the younger population [13]. They also have a variety of fruity flavors which is appealing to young adults and more likely will encourage them to try it [3].

Methods

The Population Assessment of Tobacco Health (PATH) data set will be used to evaluate the association between tobacco products and symptoms of respiratory diseases. PATH is a nationally recognized longitudinal cohort study with over 45,000 participants [16]. It collects data on current users, past users and non-users of tobacco products to assess tobacco health risk within the United States. Participants in the PATH study are interviewed in person by trained professionals who ask a variety of questions about knowledge of different tobacco products, frequency of use, and quit rates for each product. These interviewers have audio and visual representation of each tobacco devices in question. There are two sets of questionnaires that are asked by the interviewer. One set is for participants who are under the age of 18 and the other is for participants who are 18 years old and older. Participants are followed up every year or every other year [16]. The PATH study has released three waves for both the adult and youth population and is currently preparing to evaluate their participants for their fourth wave. The PATH study recruits their participants by randomly selecting residential addresses to contact. Within the household, one adult and one child are chosen to participate in PATH survey [16].

This study will evaluate participants who are under the age of 18. Wave one and two, administrated one year apart, from the PATH study will be used to evaluate the research question. In this study, there are two exposures of interests and three outcomes of interests that will be evaluated. The first exposure is tobacco user. This variable consists of six categories which are current TC users, former TC users, current EC users, former EC users' current dual users, and non-users of TC and EC. Current users were classified as using the tobacco product at least once or twice within the past 30 days. Former users were classified as participants who have ever used the tobacco product in their lifetime, but not within the past 30 days. Dual users were classified as participants who have used both EC and TC within the past 30 days, and non-users were participants who have never used EC or TC in their lifetime.

The second exposure of interest was frequent tobacco users. This variable has four categories which consist of TC users, EC users, Dual users, and non-user. TC, EC and Dual users were classified as participants who have used the tobacco product more than three times in the past 30 days. Non-users were classified as participants who have never used TC or EC in their lifetime. The three outcome variables that were used in this study were respiratory symptoms that consist of shortness of breath, wheezing and dry cough. All three outcome variables were coded at binary yes/no questions. Shortness of breath was classified as participants who have experienced being short of breath more often than their peers. Wheezing was classified as participants who have ever experienced wheezing in their lifetime. Dry cough was classified as participants who have had a dry cough that was not associated with a cold or infection in the past year.

Other variables that were analyzed in this study consist of best friend's tobacco use, parents smoking habits, age, gender, race, tobacco advertisement exposure, physical health, mental health, asthma disorder, and other health disorder. Best friend's tobacco use was coded into four categories which were used to evaluate the participant's close friends smoking status. The categories consist of smoke TC only, smoke EC only, smokes both TC and EC and doesn't smoke either TC or EC. Parent smoking habits was coded into two categories. The first category was for a parent who answered yes to smoking combustible tobacco products inside the household. The second category was for parents who answered yes to using non-combustible tobacco products or no tobacco products at all. This variable was used to evaluate second-hand exposure within the household.

Age was coded into two categories which consist of pre-teen (12 to 14) and teenagers (15-17). Gender was classified as male and female. Race was classified into four categories which consist of non-Hispanic whites, non-Hispanic blacks, Hispanics and other. Tobacco advertisement exposure was coded as a binary yes/no variable and was used to evaluate the participant's exposure to advertisements of tobacco products on social media. Self-perceptions of physical and mental health were left into five categories in which the participant evaluated their health status. The categories for these variables were excellent, very good, good, fair and poor. Asthma disorder is a binary yes/no variable that asked the participants if they have been told by a health professional that they have asthma. Other health diagnosis is also a yes/no binary variable that evaluated if the participant has been told by a health professional that they had bronchitis, pneumonia or chronic cough within the past year.

STATA version 14 was used to conduct statistical analysis to evaluate this research question. Complex survey design and weights were used to adjust for the population size. Descriptive statistics were obtained and placed. Descriptive statistics for categorical variables will have the total number of un-weighted participants in each category and the weighted percentages in relation to the population. Chi-square tests and person correlations were used to conduct the bivariate analysis. These tests will compare all covariates to all three outcomes of interest. During each comparison, p-values set at 0.05 will be obtained to determine any significant relationship between any covariates and any of the outcomes.

Six logistic regression analyses were conducted for the multivariable analysis. Within the multivariable analysis, three models were created. These models consist of the crude model, the full model, and the parsimonious model. The crude model will have the odds ratio with the 95% CI of each covariate when compared to the outcome of interest. The full model has the Odds ratio with the 95% CI between the main exposures and outcome while controlling for all of the covariates. The parsimonious model also has odds ratio with the 95% CI between the main exposures and outcome while controlling for all the covariates except for asthma diagnosis and health diagnosis. Participants who were diagnosed with asthma, bronchitis, pneumonia and chronic cough will also be excluded from the parsimonious model.

Results

This study looked at participants who were 12 to 17 years old. Table 1 is a bivariate analysis that compares all covariates to all three outcomes of interest to see if there is a significant relationship. Table 1 show that about 83% of the population has never used TC or EC in their lifetime. It shows that less than two percent of the populations are users of TC or EC. Although there is a small sample size of users of these tobacco products, 15% of the population has best friends who use tobacco. The bivariate analysis also shows that there is no significant relationship between any of the exposures of interest to any of the outcomes. It also shows that race is insignificant (p-value=0.089) when compared to participants who are short of breath. The rest of the covariates of interest are significant when compared to all three outcomes of interest.

Table 2 is a multivariate logistic regression analysis that compares tobacco products to the three outcomes of interest while controlling for all the covariates. Each outcome has three models. These models include the crude, the full and parsimonious models. The crude mode compares covariates to the outcome of interest independently without adjustments. The full model compares tobacco products to the outcome of interest while adjusting for all the covariates. The parsimonious model is similar to the full model but excludes asthma diagnosis and health diagnosis variables and participants in the study. Even when the associations between tobacco products and all three outcomes were controlled for by the covariates, there still was not a significant relationship between the exposure and outcome of interest.

Table 3 is another multivariate logistic regression analysis that assesses

Table 1. Bivariate analysis among participants aged 12-17 who uses tobacco products and all covariates compared to symptoms of respiratory diseases from the 2013-2015 United States Population Assessment of Tobacco Health Study (PATH) wave 1 and 2

	Total	Short of breath (outcome 1)			Wheezing (outcome 2)			Dry Cough (Outcome 3)		
		Yes	No		Yes	No		Yes	No	
	N (%)	n (%)	n (%)	p-value[1]	N (%)	N (%)	p-value	N (%)	N (%)	p-value[1]
Tobacco Users (exposure 1)				0.886			0.669			0.397
Current TC Users (Within 30 days)	186 (1.31)	32 (18.48)	125 (81.52)		36 (20.49)	122 (79.51)		16 (9.57)	145 (90.43)	
Past TC Users	681 (4.81)	129 (21.67)	467 (78.33)		144 (24.52)	447 (75.48)		84 (14.52)	505 (85.48)	
Current EC Users (Within 30 days)	222 (1.61)	39 (18.80)	155 (81.20)		40 (20.32)	151 (79.68)		34 (16.59)	161 (83.41)	
Past EC Users	1,003 (7.28)	188 (20.13)	702 (79.87)		200 (23.18)	688 (76.82		127 (13.74)	764 (86.26)	
Current Duel Users	196 (1.47)	38 (21.54)	135 (78.46)		45 (27.02)	27 (72.98)		20 (11.59)	157 (88.41)	
None-users	11,268 (83.50)	2,106 (20.95)	7,779 (79.05)		2,302 (23.11)	7,635 (76.89)		1474 (14.50	8494 (85.50)	
Frequent Users (Exposure 2)				0.742			0.594			0.627
TC users	373 (3.35)	63 (19.1)	246 (80.90)		77 (23.15)	235 (76.85)		41 (13.72)	275 (86.28)	
EC users	149 (1.39)	25 (18.28)	106 (81.72)		27 (19.16)	101 (80.84)		24 (17.84)	108 (82.16)	
Dual users	123 (1.17)	24 (21.64)	85 (78.36)		27 (27.04)	81 (72.96)		13 (11.65)	97 (88.35)	
Never-users	9,871 (94.08)	1,847 (20.98)	6,811 (79.02)		2015 (23.11)	6688 (76.89)		1271 (14.33)	7461 (85.67)	
Best Friends Tobacco Use				< 0.001			<0.001			<0.001
Smoke TC Only	1,188 (9.51)	329 (27.57)	845 (72.43)		330 (27.73)	849 (72.27)		231 (18.93)	950 (81.07)	
Smoke EC Only	859(7.12)	182 (20.89)	676 (79.11)		204 (23.73)	648 (76.27)		120 (14.22)	733 (85.78)	
Smoke Either TC or EC	1,884 (15.39)	563 (30.08)	1,302 (69.92)		545 (29.27)	1320 (7073)		366 (19.46)	1506 (80.54)	
Doesn't Smoke Neither	8,157 (67.97)	1,455 (17.74)	6,554 (82.26)		1684 (20.99)	6368 (79.01)		1034 (12.54)	7057 (87.46)	
Parent Smoking Habits				< 0.001			<0.001			<0.001
Smoke combustible tobacco products	3,333 (26.78)	911 (27.22)	1,614 (72.78)		944 (28.05)	2356 (71.95)		639 (19.11)	2669 (12.66)	
Doesn't smoke Combustible tobacco products	8,696 (73.22)	2,384 (18.53)	6949 (81.47)		1830 (21.54)	6769 (78.46)		1110 (80.89)	7522 (87.34)	
Age				0.002			0.131			<0.001
Pre-teen (12 to 14)	6,266 (50.70)	1,242 (19.68)	4,871 (80.32)		1456 (23.70)	4701 (76.30)		994 (15.72)	5198 (84.28)	
Teenager (15 to 17)	5,906 (49.30)	1,307 (22.05)	4,558 (77.95)		1332 (22.62)	4535 (77.38)		772 (13.00(	5104 (87.00)	
Gender				< 0.001			<0.001			0.007
Male	6,225 (51.26)	1,042 (16.53)	5,071 (83.47)		1332 (21.63)	4813 (78.37)		837 (13.42)	5333 (86.58)	
Female	5,918 (48.74)	1,499 (25.32)	4,340 (74.68)		1452 (24.81)	4400 (75.19)		923 (15.36)	4947 (84.64)	
Race				0.089			<0.001			<0.001
Non- Hispanic White	5,848 (54.15)	1219 (20.79	4539 (79.21)		1324 (22.63)	4447 (77.37)		813 (13.64)	4989 (86.36)	
Non-Hispanic Black	1,635 (13.72)	355 (22.16)	1258 (77.84)		469 (28.80)	1156 (71.20)		298 (18.15)	1327 (81.85)	
Other	1,133 (9.51)	279 (22.76)	831 (77.24)		314 (26.09)	803 (73.91)		186 (14.59)	934 (85.41)	
Hispanic	3,502 (22.62)	684 (19.41)	2763 (80.59)		669 (19.80)	2790 (80.20)		457 (13.66)	3013 (86.34)	
Exposure to tobacco products on social media				< 0.001			<0.001			<0.001
Yes	4,419 (46.08)	1,164 (26.07)	3,221 (73.93)		1223 (27.89)	3168 (72.11)		783 (17.47)	3621 (82.53)	
No	5,259 (53.92)	989 (18.54)	4,196 (81.46)		1103 (21.04)	4101 (78.97)		632 (11.82)	4595 (88.18)	
Physical Health				< 0.001			<0.001			<0.001
Excellent	4,809 (40.61)	553 (11.52)	4,195 (88.48)		848 (17.84)	3916 (82.16)		555 (11.53)	4227 (88.47)	
Very Good	4,106 (34.15)	843 (202)	3,213 (79.80)		960 (23.61)	3108 (76.39)		594 (14.26)	3482 (85.74)	
Good	2,400 (19.05)	799 (34,23)	1,558 (65.77)		696 (29.51)	1671 (70.49)		423 (17.74)	1955 (82.26)	
Fair	637 (4.98)	290 (47.36)	332 (52.64)		238 (39.77)	384 (60.23)		152 (24.40)	477 (75.60)	
Poor	155 (1.21)	58 (38.72)	91 (61.28)		39 (27.49)	109 (72.51)		32 (18.80)	118 (81.20)	
Mental health				<0.001			<0.001			<0.001
Excellent	3,674 (30.75)	403 (10.62)	3,228 (89.38)		587 (16.07)	3056 (83.93)		357 (9.45)	3303 (90.55)	
Very Good	3,403 (28.61)	563 (16.53)	2,798 (83.47)		719 (21.40)	2648 (78.60)		455 (13.34)	2919 (86.66)	
Good	2,731 (22.41)	724 (26.62)	1,957 (73.38)		702 (26.49)	2002 (73.51)		440 (16.43)	2272 (83.57)	
Fair	1,570 (12.77)	555 (35.53)	996 (64.47)		513 (32.79)	1038 (67.21)		323 (20.24)	1234 (79.76)	
Poor	673 (5.46)	288 (44.13)	370 (55.87)		254 (38.55)	402 (61.45)		176 (25.80	488 (74.20)	
Diagnosed with asthma				< 0.001			<0.001			<0.001
Yes	2,162 (17.47)	975 (45.21)	1,155 (54.79)		1387 (65.83)	751 (34.17)		549 (25.39)	1598 (74.71)	
No	9,957 (82.53)	1,563 (15.68)	8,246 (84.32)		1388 (14.09)	8463 (85.91)		1202 (11.99)	8678 (88.01)	
Had bronchitis, pneumonia or chronic cough within past year				< 0.001			<0.001			<0.001
Yes	509 (4.18)	182 (35.40)	317 (64.60)		239 (47.19)	262 (52.30)		157 (31.43)	346 (68.57)	

No	11,614 (95.82)	2,357 (20.23)	9,074 (79.77)		2538 (22.13)	8937 (77.87)		1600 (13.63)	9917 (86.37)
N is unadjusted for weights within the population									
percentages are adjusted for population weights									

Table 2. Multivaraite analysis among participants aged 12-17 who uses tobacco products and all covariates compared to shortness of breath, wheezing and dry cough from the 2013-2015 United States Population Assessment of Tobacco Health Study (PATH) wave 1 and 2

	Short of Breath			Wheezing			Dry Cough		
	Crude OR (95% CI)	Full model (N=9238)	Parsimonious model (N=7310)	Crude OR (95% CI)	Full model (N=9258)	Parsimonious model (N=7325)	Crude OR (95% CI)	Full model (N= 9292)	Parsimonious model (N=7349)
		Adjusted OR (95% CI)	Adjusted OR (95% CI)		Adjusted OR (95% CI)	Adjusted OR (95% CI)		Adjusted OR (95% CI)	Adjusted OR (95% CI)
Tobacco Users (exposure 1)									
Current TC Users (Within 30 days)	0.86 (0.57; 1.29)	0.81 (0.48; 1.37)	0.76 (0.39; 1.50)	.86 (0.58;1.27)	0.81 (0.46; 1.44)	0.99 (0.54; 1.84)	0.62 (0.36; 1.07)	0.53 (0.26; 1.08)	0.59 (0.27; 1.27)
Past TC Users	1.04 (0.83; 1.31)	1.06 (0.80; 1.40)	1.01 (0.72; 1.42)	1.08 (0.86; 1.27)	1.11 (0.85; 1.46)	1.00 (0.70; 1.42)	1.00 (0.79; 1.28)	0.99 (0.75; 1.32)	1.04 (0.75; 1.45)
Current EC Users (Within 30 days)	0.87 (0.60; 1.27)	1.10 (0.71; 1.72)	0.88 (0.51; 1.51)	0.85 (0.57;1.24)	1.10 (0.72; 1.69)	0.95 (0.53; 1.72)	1.17 (0.80; 1.72)	1.26 (0.81; 1.96)	1.05 (0.59; 1.89)
Past EC Users	0.95 (0.73; 1.46)	0.93 (0.75; 1.16)	0.93 (0.69; 1.24)	1.00 (0.85:1.19)	0.92 (0.72; 1.17)	0.96 (0.74; 1.26)	0.94 (0.76; 1.56)	1.01 (0.79; 1.28)	1.15 (0.90; 1.47)
Current Duel Users	1.04 (0.73; 1.46)	1.22 (0.83; 1.78)	1.05 (0.66; 1.66)	1.23 (0.84; 1.81)	1.44 (0.85; 2.46)	1.77 (0.98; 3.18)	0.77 (0.46; 1.29)	0.71 (0.36; 1.39)	0.85 (0.40; 1.84)
None-users	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Best Friends Tobacco Use									
Smoke TC Only	1.76 (1.53; 2.04)	1.19 (0.98; 1.46)	1.28 (1.01; 1.61)	1.44 (1.24;1.68)	1.17 (0.95; 1.45)	1.21 (0.95; 1.54)	1.63 (1.41; 1.89)	1.38 (1.14; 1.68)	1.46 (1.14; 1.86)
Smoke EC Only	1.22 (1.01; 1.48)	1.08 (0.86; 1.36)	1.03 (0.78; 1.36)	1.17 (0.99; 1.39	1.16 (0.94; 1.43)	1.26 (0.96; 1.64)	1.16 (0.93; 1.44)	1.11 (0.88; 1.43)	1.02 (0.74; 1.39)
Smoke Either TC or EC	1.99 (1.75; 2.27)	1.37 (1.18; 1.61)	1.40 (1.15; 1.70)	1.56 (1.38;1.75)	1.29 (1.08; 1.54)	1.34 (1.08; 1.66)	1.69 (1.46; 1.95)	1.35 (1.12; 1.63)	1.34 (1.10; 1.64)
Doesn't Smoke Neither	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Parent Smoking Habits									
Smoke combustible tobacco products	1.64 (1.48;1.83)	1.32 (1.15; 1.52)	1.37 (1.16; 1.61)	1.42 (1.29; 1.56)	1.22 (1.06; 1.39)	1.28 (1.08; 1.51)	1.63 (1.42; 1.86)	1.44 (1.22; 1.70)	1.53 (1.27; 1.85)
Doesn't smoke Combustible tobacco products	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Age									
Pre-teen (12 to 14)	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Teenager (15 to 17)	1.15 (1.05; 1.26)	0.90 (0.79; 1.02)	0.91 (0.79; 1.61)	0.94 (0.87; 1.02)	0.71 (0.63; 0.80)	0.69 (0.59; 0.88)	0.80 (0.71; 0.90)	0.66 (0.57; 0.76)	0.60 (0.51; 0.72)
Gender									
Male	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Female	1.71 (1.56; 1.87)	1.63 (1.45; 1.83)	1.55 (1.34; 1.79)	1.19 (1.10:1.30)	1.18 (1.04; 1.34)	1.07 (0.93; 1.24)	1.17 (1.04; 1.31)	1.10 (0.96; 1.26)	1.08 (0.92; 1.26)
Race									
Non- Hispanic White	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Non-Hispanic Black	1.08 (0.94; 1.25)	1.04 (0.86; 1.26)	1.09 (0.88; 1.34)	1.38 (1.22; 1.57)	1.40 (1.17; 1.67)	1.33 (1.08; 1.64)	1.40 (1.22; 1.62)	1.31 (1.11; 1.56)	1.35 (1.10; 1.67)
Other	1.12 (0.94; 1.34)	1.14 (0.95; 1.38)	1.04 (0.81; 1.33)	1.21 (1.04; 1.39)	1.15 (0.98; 1.35)	1.02 (0.80; 1.30)	1.08 (0.87; 1.35)	1.12 (0.85; 1.49)	1.11 (0.80; 1.55)
Hispanic	0.92 (0.81; 1.03)	0.83 (0.72; 0.95)	0.82 (0.69; 0.96)	0.84 (0.75; 0.95)	0.79 (0.68; 0.91)	0.74 (0.62; 0.88)	1.00 (0.87:1.16)	0.99 (0.84; 1.16)	0.96 (0.78; 1.18)
Tobacco Advertisements exposure									
Yes	1.55 (1.41; 1.71)	1.30 (0.86; 1.26)	0.74 (0.64; 0.85)	1.45 (1.33; 1.58)	1.38 (1.24; 1.55)	0.73 (0.63; 1.33)	1.58 (1.38; 1.81)	1.46 (1.27; 1.68)	0.69 (0.58; 0.81)
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Physical Health									
Excellent	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Very Good	1.94 (1.69; 2.24)	1.51 (1.27; 1.79)	1.62 (1.26; 2.08)	1.42 (1.26; 1.60)	1.10 (0.93; 1.29)	1.12 (0.95; 1.33)	1.28 (1.13; 1.44)	1.00 (0.86; 1.16)	0.93 (0.77; 1.13)
Good	4.00 (3.52; 4.54)	2.71 (2.32; 3.17)	2.55 (2.01; 3.23)	1.93 (1.71;2.17)	1.27 (1.06; 1.52)	1.38 (1.14; 1.68)	1.65 (1.41: 1.93)	1.09 (0.89; 1.33)	1.03 (0.79; 1.35)
Fair	6.91 (5.63; 8.48)	3.87 (3.02; 4.95)	2.86 (2.17; 3.78)	3.04 (2.50; 3.70)	1.86 (1.38; 2.49)	1.86 (1.33; 2.62)	2.47 (2.00: 3.05)	1.49 (1.13; 1.97)	1.35 (0.98; 1.85)

Poor	4.85 (3.37; 7.00)	2.65 (1.50; 4.70)	2.92 (1.45; 5.91)	1.75 (1.18; 2.57)	0.77 (0.44; 1.34)	0.71 (0.30; 1.70)	1.78 (1.17; 2.70)	1.06 (0.59; 1.91)	0.74 (0.29; 1.88)
Mental health									
Excellent	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Very Good	1.67 (1.44;1.93)	1.35 (1.12; 1.61)	1.62 (1.26; 2.08)	1.43 (1.25; 1.62)	1.45 (1.24; 1.72)	1.73 (1.38; 2.17)	1.47 (1.25; 1.73)	1.41 (1.15; 1.73)	1.53 (1.21; 1.95)
Good	3.05 (2.61; 3.58)	1.96 (1.62;2.37)	2.55 (2.01; 3.23)	1.88 (1.66; 2.14)	1.68 (1.39; 2.02)	2.05 (1.66; 2.53)	1.88 (1.62; 2.19)	1.70 (1.41; 2.05)	2.14 (1.69; 2.70)
Fair	4.64 (3.95; 5.45)	2.41 (1.96; 2.96)	2.86 (2.17; 3.78)	2.55 (2.20; 2.95)	2.11 (1.74; 2.56)	2.55 (2.05; 3.17)	2.43 (2.04; 2.89)	1.88 (1.46; 2.42)	2.27 (1.68; 3.08)
Poor	6.65 (5.40; 8.18)	3.85 (2.95; 5.01)	4.93 (3.49; 6.97)	3.28 (2.71; 3.96)	3.03 (2.26; 4.06)	3.87 (2.69; 5.57)	3.33 (2.66; 4.17)	2.75 (2.04; 3.71)	3.99 (2.88; 5.54)
Asthma Disorder									
Yes	4.44 (3.97; 4.96)	4.38 (3.83; 5.02)	-	11.74 (10.40; 13.25)	11.76 (10.03; 13.79)	-	2.48 (2.22; 2.79)	2.04 (1.76; 2.38)	-
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Other Health Disorders									
Yes	2.16 (1.73; 2.71)	1.32 (0.99; 1.77)	-	3.14 (2.52; 3.92)	1.97 (1.41; 2.76)	-	2.91 (2.44; 3.45)	2.26 (1.76; 2.92)	-
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
OR = Odds ratio									
95% CI = 95% Confidence Interval									
N is unadjusted for weight within the population									
percentages are adjusted for population weights									
p-value is set at significant level of 0.05									

Table 3. Multivariate analysis among participants aged 12-17 frequency of tobacco products and all covariates compared to shortness of breath, wheezing and fry cough from the 2013-2015 United States Population Assessment of Tobacco Health Study (PATH) wave 1 and 2.

	Traditinal Cigarettes N (%)	Electronic Cigarettes N (%)	Duel Users N (%)	Non-users N (%)	Total N (%)
Doesn't have Asthma	268 (2.85)	115 (1.23)	91 (0.98)	7207 (77.58)	7681 (82.64)
Diagnoised with Asthma	47 (0.47)	17 (0.16)	20 (0.19)	1565 (16.53)	1649 (17.36)
Total	315 (3.32)	132 (1.40)	111 (1.18)	8772 (94.11)	9330 (100)

Table 4: Distrubution between frequency of tobacco use and particpants who were diagnosied with asthma

	Traditinal Cigarettes N (%)	Electronic Cigarettes N (%)	Duel Users N (%)	Non-users N (%)	Total N (%)
Doesn't have Asthma	268 (2.85)	115 (1.23)	91 (0.98)	7207 (77.58)	7681 (82.64)
Diagnoised with Asthma	47 (0.47)	17 (0.16)	20 (0.19)	1565 (16.53)	1649 (17.36)
Total	315 (3.32)	132 (1.40)	111 (1.18)	8772 (94.11)	9330 (100)

the relationship between the frequency of tobacco use to all the outcomes while controlling for all the covariates. In table three, frequency use of tobacco products remains insignificant at the 0.05 p-value level when compared to all three outcomes of interest. Parent's smoking habits, mental health, and diagnosed asthma have remained significant throughout all models with all the outcomes. All the other covariates varied in significance levels. When table 2 was compared to table 3, the increased frequency in tobacco use odds ratios and 95% Confidence intervals were similar to table two's values. Table 4 shows the distribution between people who have asthma and people who use tobacco products more than three times in the past 30 days.

Discussion

The goal of this study is to evaluate the potential effects that EC can have on the youth population's respiratory status. When testing the association between EC and symptoms of respiratory diseases, controlling for all covariates, the results show that there is no statistically significant relationship between the two exposures and the three outcomes of interest.

One possible reason for these results can be the sample size. In the PATH study, there is a low sample size of participants who only use EC and never used TC. Table 1 shows the bivariate distribution between the exposure and outcomes. In Table 1, out of 13,000 participants who participated in the survey, there were 32 individuals who are current TC users that experienced shortness of breath, 40 current EC users who experienced wheezing and 20 dual users who experienced dry coughs. TC is known to cause respiratory diseases, but the numbers in Table 1 does not show any association even among TC users due to the low sample size. The participants were also young and not exposed to TC products for very long

It is also possible that the participants in the study have not been using the products long enough to see an effect. Another reason for these results is the classification of current users for electronic cigarettes within the youth population. The PATH study identifies current users as participants who smoke at least once or twice within the past thirty days. This is a limitation because one electronic cigarette might not be enough to see an effect on the participant's health status. There is no clear definition of what classifies someone as a frequent user of tobacco products in the youth population. To control this, a second exposure variable (frequency of tobacco use) was created to determine if increase use in the tobacco products would result in the development of respiratory symptoms. However, the multivariable analysis between Table 2 and Table 3 results shows that there is not much of difference in terms of association or odds ratios.

The PATH study dataset receives its information from the surveys they distribute. Due to this, the study is susceptible to other limitations such as

recall bias, and socially desirable bias. To minimize these biases, participants of the PATH study had an audio and visual aide to help participants answer the survey questions. The benefits of using the PATH study are that it is a large nationally recognized data set with a high number of participants. There are multiple waves which mean it can be used to evaluate trends over time. It also has information on different types of tobacco products that can be used for comparison.

Conclusion

The constant debate about the benefits and risk of EC within the population is ongoing. The populations who can benefit from this new trend are current smokers, while populations who are at the most risk are non-smokers. The major gap in previous literature is that the sample sizes for participants who only smoke electronic cigarettes are very low. Another gap is that electronic cigarettes have only been around for less than ten years. To determine if electronic cigarettes are a public health issue, constant surveillance is needed to evaluate trends over time. Until more people start using EC and more time has passed, it is difficult to determine if the risk outweighs the benefits of electronic cigarette use.

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