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Adolescent Perceptions of E-cigarette Use and Vaping Behavior Before and After the EVALI Outbreak

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Abstract

This study sought to determine whether adolescents' e-cigarette risk perceptions, perceived benefits, and positive expectations, and vaping behavior changed after the electronic-cigarette or vaping product use-associated lung injury (EVALI) outbreak. This longitudinal survey studied 1539 high school students in suburban Philadelphia, PA in 11th and 12th grade, before and after the outbreak of EVALI cases in 2019. Adolescents who reported current nicotine vaping at baseline (versus those who did not) had a greater increase in risk perceptions (B= −0.31, p=0.04) and a greater decrease in positive expectations (B= −1.30, p=0.003) at follow-up. Adolescents who reported current marijuana vaping at baseline (versus those who did not) had greater perceived benefits (B=2.19, p<0.001), lower risk perceptions (B=0.39, p<0.001), and greater positive expectations of e-cigarette use (B=1.43, p<0.001) across time. Odds of current nicotine vaping at follow-up increased (OR=1.61, 95% CI= 1.08, 2.41) for adolescents who maintained lower risk perceptions. Odds of current nicotine vaping at follow-up decreased (OR=0.33, 95% CI=0.21, 0.50) for adolescents whose positive expectations of e-cigarette use decreased. The odds of current marijuana vaping at follow-up decreased (OR=0.64, 95% CI=0.42, 0.98) for adolescents whose positive expectations of e-cigarette use decreased. Perceptions of the risks of e-cigarette use increased and positive expectations of e-cigarette use decreased after the EVALI outbreak. Adolescent risk perceptions and positive expectations of e-cigarette use are two potential targets

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to impact vaping behavior. Emphasizing the risks of e-cigarette use while decreasing positive expectations of use have the potential to reduce vaping behavior, and perhaps subsequent EVALI cases.

Keywords

adolescent; e-cigarette; marijuana; EVALI; perceptions; longitudinal studies

INTRODUCTION

E-cigarettes are the most commonly used tobacco product among adolescents in high school (Cherian et al., 2020; Cullen et al., 2019b). In 2019, approximately 20% of adolescents used an e-cigarette to vape nicotine within the past 30 days (Johnston et al., 2020). Additionally, as e-cigarettes have risen in popularity, adolescents are more likely to use e-cigarette devices to vape marijuana (Patrick et al., 2020; Trivers et al., 2018). Recent surveillance estimates indicate that 23% of adolescents in high school have ever vaped marijuana, while over 13% vaped marijuana in the past 30 days (Miech et al., 2020).

A frequently cited reason for vaping nicotine among young people is the perception that e-cigarettes are less harmful than conventional cigarettes (Jankowski et al., 2019; National Academies of Sciences and Medicine, 2018). Likewise, 66% of adolescents who prefer vaping over smoking marijuana believe that vaping is healthier (Knapp et al., 2019). In August of 2019, the first case of electronic-cigarette, or vaping, product use-associated lung injury (EVALI) was officially reported to the Centers for Disease Control (Hartnett et al., 2019). EVALI is characterized by a gradual onset of respiratory symptoms, which often include gastrointestinal symptoms, fever, headaches, weight loss, muscle aches, and fatigue (Adkins et al., 2020; Kalkhoran et al., 2020; Krishnasamy, 2020). Twenty-eight percent (28.0%) of adolescent EVALI patients reported exclusively vaping THC-containing e-cigarettes (THC, tetrahydrocannabinol, the psychoactive compound in marijuana), 10.9% reported exclusively using nicotine-containing e-cigarettes, and approximately 50.8% reported using both (Adkins et al., 2020).

As the frequency of reported cases continued to rise (Krishnasamy, 2020), media coverage amplified vaping-related harms, which likely increased the perceptions of the risks associated with vaping. Indeed, internet searches for e-cigarette cessation strategies among adults were 3.7 times higher than the expected trends before the EVALI outbreak and remained elevated for months (Kalkhoran et al., 2020). Yet, the impact of the EVALI outbreak on adolescents' risk perceptions of and motivations for e-cigarette use, as well as vaping behavior, is not yet known.

This prospective cohort survey study of adolescents in high school sought to determine whether adolescents' perceived benefits, risk perceptions, and positive expectations of e-cigarette use, and vaping behavior changed after the EVALI outbreak. Cognitive and social learning models suggest that adolescents who perceive fewer harms associated with vaping, perceive more reasons to vape, and anticipate positive outcomes of vaping will be more likely to vape (Shadel et al., 2000). Environmental events such as media

coverage of the development of EVALI in young people can alter cognitive perceptions of vaping (Shadel et al., 2000). Changes in these perceptions, in turn, can impact adolescent vaping behavior (Baranowski et al., 2002). Such perceptions can also be influenced by the social environment (e.g., peer support for vaping), characteristics of the adolescent (e.g., a disposition to seek out reinforcing stimuli like nicotine and marijuana), and other behaviors (e.g., exposure to other forms of nicotine delivery such as combustible cigarettes). Documenting changes in adolescent perceptions of vaping and vaping behavior that surrounded the outbreak may help inform efforts to reduce nicotine and marijuana vaping, and possibly prevent EVALI.

METHODS

Participants and Procedures

Participants were 11th-grade students from four high schools in the suburban Philadelphia, PA area followed as part of a longitudinal survey study of e-cigarette, combustible cigarette, and other tobacco use (Audrain-McGovern, Rodriguez, Alexander, et al., 2019). Data were collected at seven semiannual assessments starting in the fall of 2016 when the cohort was beginning 9th grade, through the fall of 2019 when the cohort was beginning 12th grade. The present study focused on the 6th (spring 2019) and the 7th assessment (fall 2019), which corresponded to the time period immediately preceding the first reported EVALI case and after the majority of cases were reported. For the present study, the 6th assessment served as the baseline and the 7th assessment served as the 6-month follow-up. Adolescents who provided data at both of these waves comprised the analytic sample (N=1539). All data were collected via paper and pencil surveys at the participants' high schools. Parental consent (active information - passive parental consent) and written adolescent assent were obtained. The Institutional Review Board of the University of Pennsylvania and the administration of each of the four high schools approved the study.

Measures

E-cigarette Use.—The survey included an introduction explaining what e-cigarettes are, and the types of products or devices that are classified as e-cigarettes. Images of different e-cigarette devices were provided for clarity (Audrain-McGovern, Rodriguez, Pianin, et al., 2019; Conway et al., 2018). These images included e-cigarettes, e-hookahs, vape pens, mods, and USB-style pod vaporizers. The instructions for the survey section devoted to the assessment of e-cigarette use read, "The questions ask about using any of the e-cigarette devices pictured to vape e-liquid, NOT marijuana." "Excluding using an e-cigarette device for vaping marijuana, have you ever used an e-cigarette like the ones pictured above, even 1 or 2 times?" Adolescents who reported ever using e-cigarettes were then prompted to answer a series of epidemiological questions assessing current use (i.e., use on at least one day in the past 30 days) (Audrain-McGovern et al., 2018; Cullen et al., 2019a; Wang et al., 2019).

Marijuana Vaping.—Similar to the assessment of e-cigarette use, adolescents were asked: "Have you ever used an e-cigarette device like the ones pictured above to vape marijuana (plant, wax, oil, or THC), even 1 or 2 times?" Adolescents who reported ever using an e-cigarette device to vape marijuana were prompted to answer a series of epidemiological

questions assessing current use (i.e., use on at least one day in the past 30 days) (Audrain-McGovern et al., 2018; Wang et al., 2019).

Risk Perceptions.—Risk perceptions associated with e-cigarette use (relative to combustible cigarettes) were measured with two Likert-style items (0=strongly disagree to 3=strongly agree) derived from previous research (i.e., e-cigarettes might be less harmful for people to be around than cigarettes, e-cigarettes might be less addictive than cigarettes) (Camenga et al., 2017; Saddleson et al., 2015; Waters et al., 2017). Higher scores indicated lower perceived risks. Perceived relative risk of e-cigarette use has been associated with lifetime e-cigarette, current e-cigarette use, and exclusive e-cigarette use versus polytobacco use in adolescent and adult samples (Bernat et al., 2018; Persoskie et al., 2017; Wang et al., 2018). The Cronbach's coefficient alpha for this two-item scale was .65.

Perceived Benefits.—Perceived benefits of using e-cigarettes were measured with 12 items using a Likert-scale (0=strongly disagree to 3=strongly agree). Items assessed available flavors, smell, affordability, impact on non-tobacco users, substitution in smoke-free situations, and similarity to smoking (Gibson et al., 2018; Trumbo & Harper, 2013). Higher scores indicated greater perceived benefits. Perceived benefits have been associated with susceptibility to e-cigarette use, initiating use, past 30-day use, and continued e-cigarette use among youth (Bernat et al., 2018; Vogel et al., 2019). The Cronbach's coefficient alpha for this two-item scale was.89.

Positive Expectations.—Positive expectations of e-cigarette use were measured with a 9-item Likert-style scale (Gibson et al., 2018; Harrell et al., 2015; Wills et al., 2015). The items included "I think vaping e-cigarettes would…give me something to do when I'm bored, …help me deal with problems or stress, …feel more comfortable at parties." Response options ranged from 0=strongly disagree to 3=strongly agree with higher scores indicating more positive expectations. Positive expectations of e-cigarette use have been shown to correlate with past year, irregular, and regular e-cigarette use (Gibson et al., 2018; Soule et al., 2020). Cronbach's coefficient alpha for this scale is .83.

Baseline Covariates.—Demographic characteristics such as sex, race, and ethnicity were assessed using self-report items and these variables were included in the model to characterize the sample. Peer vaping acceptance was measured with the item "How many of your friends think it's OK for someone your age to use e-cigarettes?" (0=none, 1=one or more). Sensation seeking was measured with the 8-item Brief Sensation Seeking Scale (0=strongly disagree to 4=strongly agree) (Hoyle et al., 2002). Combustible cigarette smoking was assessed by asking adolescents if they had ever tried smoking a cigarette. Adolescents who indicated ever using a cigarette were then asked if they had smoked a cigarette in the past 6-months (Audrain-McGovern et al., 2018; Wang et al., 2019). The effects of peer e-cigarette vaping acceptance, cigarette smoking, and sensation seeking were controlled for in the models given their associations with vaping perceptions and behavior (Audrain-McGovern et al., 2020; Gibson et al., 2018; Trumbo & Harper, 2013).

Data Analyses

Preliminary analyses included descriptive statistics (e.g., means, standard deviations, and frequencies) and the assessment of distributional assumptions. Primary analyses involved generalized-linear mixed modeling, with a random intercept to assess changes in e-cigarette risk perceptions, perceived benefits, and positive expectations before and after the identification of EVALI. Models were initially tested without covariates (unadjusted models) and were then adjusted for baseline 30-day nicotine vaping (yes/no), 30-day marijuana vaping (yes/no), as well as baseline covariates.

Generalized-linear mixed modeling with a random intercept was also utilized to evaluate the effects of EVALI-associated changes in e-cigarette risk perceptions, positive expectations, and perceived benefits on 30-day nicotine vaping and 30-day marijuana vaping, with a logit link for the binary (Yes/No) outcome variables (binomial distribution). Binary change scores were created for e-cigarette risk perceptions, positive expectations, and perceived benefits by calculating the difference between baseline to follow-up. A value was then assigned as follows: e-cigarette risk perceptions (0=no change or decrease, 1=increase), positive expectations (0=no change or increase, 1=decrease), and perceived benefits (0=no change or increase, 1=decrease). Models were initially tested without covariates (unadjusted models) and were then adjusted for change in 30-day nicotine vaping, change in 30-day marijuana vaping, and baseline covariates.

RESULTS

Among the 2017 total adolescents eligible to participate in the cohort study at its onset (9th grade, age 14 years old), 2000 received parental consent, and 1835 of those with consent provided assent. Forty-one potential participants declined to assent and 124 were absent on both assent/survey days. Of the 1835 adolescents who completed a survey at the study outset, 1539 (84%) completed both the 11th-grade spring (baseline for this study) and 12th-grade fall assessments (6-month follow-up for this study). The 1539 adolescents who were present at the 11th-grade spring survey did not differ from those 1835 adolescents who were present at study onset on any of the study-related variables.

The sample characteristics are presented in Table 1. The adolescents were 16.7 years old (SD= 0.55) on average. Approximately 74% of the sample (n=1145) was white and 18% (n=278) was Hispanic. There was little difference from baseline to follow-up in reported past 30-day nicotine vaping [11.2% (n=173) vs. 11.1% (n=171), respectively] and 30-day marijuana vaping [(11.8% (n=181) vs. 10.6% (n=163), respectively)].

Before and After the EVALI Outbreak: Changes in E-Cigarette Risk Perceptions, Perceived Benefits, and Positive Expectations

Table 2 presents the results of unadjusted and adjusted independent models evaluating changes in perceived benefits, perceived risks, and positive expectations of e-cigarette use from baseline to the 6-month follow-up. The model evaluating changes in perceived benefits of e-cigarette use revealed main effects of nicotine vaping and marijuana vaping, even after adjusting for baseline covariates. Both the adolescents who reported past 30-day nicotine

vaping at baseline and those adolescents who reported past 30-day marijuana vaping at baseline had greater perceived benefits of e-cigarette use across time than adolescents who reported not vaping nicotine or marijuana at baseline (nicotine vaping, B= 1.61, $p<0.001$; marijuana vaping, B= 2.19, $p<0.001$).

The model examining changes in perceived risk of e-cigarette use from baseline to the 6-month follow-up revealed main effects of nicotine vaping and marijuana vaping. Adolescents who reported past 30-day nicotine vaping (B= 0.58, $p<0.001$) or past 30-day marijuana vaping (B= 0.39, $p<0.001$) at baseline had lower risk perceptions across time in the adjusted model. There was also a significant nicotine vaping by time interaction (B=−0.31, $p=0.04$) in the adjusted model. Adolescents who vaped nicotine in the past 30-days at baseline had a greater increase in risk perceptions (3.00 to 2.47) at follow-up than adolescents who did not vape nicotine in the past 30 days (2.37 to 2.07). Here, higher scores equate to lower perceived risks.

The model examining changes in positive expectations of e-cigarette use from baseline to the 6-month follow-up showed that past 30-day nicotine vaping (B=4.29, $p<0.001$) and marijuana vaping (B=1.43, $p<0.001$) at baseline were associated with greater positive expectations across time in the adjusted model. There was also a significant nicotine vaping by time interaction (B=−1.30, $p=0.003$) in the adjusted model. Adolescents who vaped nicotine in the past 30-days at baseline had a greater decrease in positive expectations at follow-up (13.02 to 11.53) than adolescents who did not vape nicotine in the past 30 days (8.02 to 7.82).

Effects of Changes in E-Cigarette Risk Perceptions, Perceived Benefits, and Positive Expectations on 30-Day Vaping Behavior.

Table 3 presents the results of unadjusted and adjusted models evaluating if changes in perceptions of e-cigarette use were associated with 30-day nicotine vaping and 30-day marijuana vaping from baseline to the 6-month follow-up. The adjusted model evaluating changes in nicotine vaping revealed a main effect of perceived risk and a time by positive expectations interaction. Adolescents who perceived fewer harms associated with e-cigarette use had a 61% increase in the odds of 30-day nicotine vaping at follow-up (OR=1.61, 95% CI=1.08, 2.41). The odds of vaping nicotine in the past 30-days (versus not vaping) decreased 67% (OR=0.33, 95% CI=0.21, 0.50) at follow-up for adolescents whose positive expectations of e-cigarette use decreased (versus increased or remained unchanged) from baseline to 6-month follow-up. Past 30-day marijuana vaping was associated with more than a five-fold increase in the odds of 30-day nicotine vaping over time (OR=5.43, 95% CI= 3.34, 12.85).

The adjusted model evaluating changes in marijuana vaping from baseline to the 6-month follow-up revealed a significant time by positive expectations interaction. The odds of vaping marijuana in the past 30-days (versus not vaping) decreased 36% (OR=0.64, 95% CI=0.42, 0.98) at follow-up for those adolescents whose positive expectations of e-cigarette use decreased (versus increased or remained unchanged) from baseline to 6-month follow-up. Past 30-day nicotine vaping was associated with an almost four-fold increase in the odds of vaping marijuana (OR=3.90, 95% CI=2.36, 6.44) at the 6-month follow-up.

DISCUSSION

This study provides the first evidence for changes in adolescent e-cigarette use perceptions after the EVALI outbreak, and associations between these changes and the odds of current nicotine vaping and marijuana vaping. Risk perceptions and positive expectations of e-cigarette use appear to be two promising targets to reduce adolescent nicotine vaping and marijuana vaping, and possibly prevent EVALI.

Cross-sectional studies have documented that adolescent e-cigarettes users are less aware of the harms that e-cigarettes pose for the user and perceive fewer harms associated with use than never-users (Amrock et al., 2015; Bernat et al., 2018; Sontag et al., 2019). A recent study found that 60% of adolescents perceived that e-cigarettes could cause at least some harm to users, while only 32% of e-cigarette users held this perception (Sontag et al., 2019). The findings of the present study indicated that risk perceptions can change among adolescent e-cigarette users. Adolescents who currently vaped nicotine prior to the EVALI outbreak showed a greater increase in e-cigarette use risk perceptions after the outbreak than adolescents who did not vape. Widespread news coverage of EVALI-related hospitalizations may have increased awareness and perceived harms of e-cigarette use among users. Indeed, respiratory harms such as lung disease discouraged more adults from e-cigarette use than any other health harm (Rohde et al., 2019). The importance of risk perceptions for vaping behavior is highlighted by the finding that adolescents who continued to perceive fewer harms associated with e-cigarette use had a 61% increase in the likelihood of current nicotine vaping six months later.

Adolescents who have ever used e-cigarettes tend to have more positive expectations of use than never users (Bernat et al., 2018). Beliefs about the positive effects of substance use are thought to be key drivers of substance use behavior (Brandon et al., 2004). As such, diminished expectations should translate to reductions in behavior. Adolescents who vaped nicotine before the EVALI outbreak had a greater decrease in positive expectations of e-cigarette use after the outbreak than adolescents who did not vape. Adolescents whose positive expectations of e-cigarette use decreased had a 67% reduction in the likelihood of currently vaping nicotine and a 36% reduction in the likelihood of vaping marijuana six months later. Expectations of enjoyment, something to do when bored, or a way to deal with stress may have lessened in the context of EVALI, especially if peer views on vaping behavior were altered. It is also possible that negative expectations of use or EVALI risk beliefs, such as hospitalization, respiratory failure, and death from EVALI increased. These potential negative expectations may have been salient as adolescents and emerging young adults comprised over 50% of the reported EVALI cases (Adkins et al., 2020). Unfortunately, neither negative expectations of e-cigarette use or EVALI risk beliefs were measured.

The impact of diminished positive expectations of e-cigarette use on marijuana vaping was smaller in magnitude than on nicotine vaping. The observed effect might reflect that the measured expectations regarding vaping e-cigarettes may have better-represented nicotine vaping than marijuana vaping (e.g., vaping e-cigs would help me stay thin, using e-cigs would make me look more mature).

Adolescents who vaped marijuana prior to the EVALI outbreak maintained fewer perceived risks and greater perceived benefits of e-cigarette use than adolescents who did not vape marijuana. A key reason for vaping nicotine and for vaping marijuana is the perception that vaping is less harmful than smoking combustible cigarettes (Jankowski et al., 2019; National Academies of Sciences and Medicine, 2018) and healthier than smoking combustible marijuana (Knapp et al., 2019). The benefits of vaping may be particularly salient for adolescents who vape marijuana (e.g., less odor, easier to conceal, affects others less) and adolescents who vape both substances.

We observed significant overlap among the adolescents who vaped nicotine and those who vaped marijuana, reflecting how common co-use is for these two substances (Audrain-McGovern et al., 2018). Over 60% percent of adolescents who vaped nicotine also vaped marijuana. These adolescents tended to be white (75%), non-Hispanic (81%), and male (59%). Recent research found that adolescents who reported vaping nicotine in the past 30 days, compared to those who did not, were over three times more likely to have ever vaped marijuana (Kowitt et al., 2019; Trivers et al., 2018). Similarly, when asked about vaping behavior in the past 30 days, 30% of adolescents who reported vaping nicotine concurrently reported vaping marijuana (Dai & Siahpush, 2020). The present study adds to this literature by documenting a 4-fold to a 5-fold increased risk that vaping one substance had on the risk of vaping the other. Further investigation into the relationship between marijuana vaping and nicotine vaping is merited. Overlap in the method of use and enhanced rewarding effects resulting from THC and nicotine interactions support dual-use and increased likelihood of becoming dependent on both substances (Agrawal et al., 2012; Rubinstein et al., 2014; Valjent et al., 2002). As such, policies that impact the use of one of these substances may impact the other.

The present findings regarding perceived risks and positive expectations on vaping behavior have several clinical and public health implications. One, educating adolescents regarding the potential harms of vaping one or both substances (e.g., EVALI, nicotine dependence, cannabis dependence) is warranted. Two, while there is strong evidence that EVALI is associated with the use of Vitamin E acetate in black market e-liquid formulations containing THC, the exact causes remain unclear (Krishnasamy, 2020). It will be important to continue to emphasize that until the cause of EVALI is fully understood, abstinence from all vaping products is the best means to prevent vaping associated lung injury. This message will need to be carefully crafted to prevent adolescents from transitioning from e-cigarettes as a nicotine delivery device to another form of nicotine delivery with greater risks. Three, positive expectations of e-cigarette use should be addressed and perhaps balanced with negative expectations of use. Four, given the overlap in vaping products, it is important to assess for nicotine vaping as well as marijuana vaping among adolescents.

As the first study to document changes in vaping perceptions and behavior surrounding the identification of EVALI cases, the strengths of this investigation include a large sample, excellent participation and retention rates, a distinct assessment of nicotine vaping and marijuana vaping, and control for variables that could account for changes in e-cigarette use perceptions and the likelihood of vaping. It is important to note that our sample was predominately white and investigations of e-cigarette perceptions and vaping behavior are

warranted in subgroups not sufficiently represented in this study. Although our sample was drawn from four high schools, the prevalence of nicotine vaping observed in the present study are consistent with state and national prevalence estimates observed in the Youth Risk Behavior Survey (Kann et al., 2018). While the prevalence of nicotine vaping observed in the present study is slightly lower than that reported in the Monitoring the Future survey, the prevalence of marijuana vaping is comparable (Johnston et al., 2020).

One important limitation is that we did not assess awareness of EVALI or media exposure of EVALI cases at follow-up. As such, we are not able to determine the direct impact of EVALI on adolescent perceptions and behavior, or if any of the observed effects were causal. Recent research has documented that news articles warning about vaping dangers increased 130% between July 25th, 2019 and September 27th, 2019 (Leas et al., 2020). While we assume this created increased awareness of EVALI among young people, we are not aware of any data on exposure to EVALI information through these news stories, or formal and/or informal health education programming through parents, teachers, coaches, or others in the community.

CONCLUSIONS

Adolescent e-cigarette use perceptions and the odds of vaping nicotine or vaping marijuana changed from before to after the EVALI outbreak. Associations between changes in adolescent perceptions of the risks of e-cigarette use and positive expectations of e-cigarette use and adolescent vaping behaviors emphasize variables for public health and adolescent medicine practitioners to target to impact vaping behavior. Emphasizing the risks of e-cigarette use while decreasing positive expectations of use have the potential to reduce vaping behavior, and perhaps subsequent EVALI cases.

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Abbreviations:

EVALI	Electronic-cigarette, or vaping, product use-associated lung injury
OR	Odds Ratio
CI	Confidence Interval

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Highlights

- Risk perceptions of e-cigarette use increased after the EVALI outbreak
- Positive expectations of e-cigarette use decreased after the EVALI outbreak
- Changes were associated with the odds of vaping nicotine or marijuana at follow-up

Table 1.

Characteristics of Study Sample at Baseline (N = 1539).

Categorical Variables	Level	No. (%)
Sex	Male	770 (50.0)
	Female	769 (50.0)
Race	White	1145 (74.4)
	Black	196 (12.7)
	Other	198 (12.9)
Ethnicity	Hispanic	278 (18.1)
	Non-Hispanic	1261 (81.9)
Nicotine Vaping	Did not use in past 30 days	1366 (88.8)
	Used in past 30 days	173 (11.2)
Marijuana Vaping	Did not use in the past 30 days	1358 (88.2)
	Used in the past 30 days	181 (11.8)
Cigarette Smoking	Did not smoke in past 6 months	1499 (97.4)
	Smoked in past 6 months	40 (2.6)
Peer Vaping	None	661 (42.9)
	One or more	878 (57.1)
Continuous Variables	**Mean (SD)**	**Range**
Risk Perceptions	2.13 (1.47)	0 – 6
Perceived Benefits	12.00 (6.04)	0 – 33
Positive Expectations	7.36 (4.40)	0 – 22
Sensation Seeking	13.86 (7.03)	0 – 32

Table 2.

Changes in E-Cigarette Perceptions and Expectations before and after the EVALI Outbreak

	Perceived Benefits			Perceived Risks			Positive Expectations		
		95% CI			95% CI			95% CI	
	B	Lower	Upper	B	Lower	Upper	B	Lower	Upper
Unadjusted model									
(Intercept)	11.43	11.11	11.74	2.00	1.92	2.07	6.87	6.65	7.10
Time	−0.18	−0.48	0.13	0.15	−0.22	−0.07	0.06	−0.27	0.14
Baseline nicotine vaping[a]	4.99	4.20	5.79	1.20	0.99	1.40	6.22	5.65	6.78
Nicotine vaping by time interaction	−1.16	−2.07	−0.25	0.43	−0.68	−0.19	1.48	−2.14	−0.82
Unadjusted model									
(Intercept)	11.39	11.08	11.71	2.00	1.93	2.08	6.98	6.76	7.21
Time	−0.17	−0.48	0.14	0.15	−0.23	−0.08	0.10	−0.31	0.10
Baseline Marijuana vaping[b]	5.07	4.29	5.84	1.09	0.89	1.29	4.98	4.31	5.65
Marijuana vaping by time interaction	−1.16	−2.03	−0.29	0.38	−0.62	−0.15	1.07	−1.73	−0.42
Adjusted model									
(Intercept)	8.05	7.14	8.96	1.34	1.12	1.56	5.54	4.91	6.17
Time	−0.16	−0.47	0.15	0.14	−0.22	−0.06	0.02	−0.23	0.18
Sex[c]	−0.45	−0.94	0.05	0.19	−0.31	−0.07	0.62	−0.98	−0.27
Black race[d]	0.09	−0.71	0.90	0.07	−0.11	0.26	0.40	−0.10	0.89
Other race[e]	−0.10	−0.80	0.59	0.01	−0.18	0.16	0.05	−0.47	0.57
Ethnicity[f]	−0.38	−1.05	0.29	0.04	−0.20	0.13	0.6	−1.06	−0.15
Cigarette smoking[g]	0.58	−0.95	2.11	0.02	−0.41	0.37	1.79	0.61	2.97
Peer vaping acceptance[h]	3.10	2.56	3.64	0.55	0.42	0.68	1.08	0.70	1.45
Sensation seeking	0.16	0.13	0.20	0.04	0.03	0.04	0.10	0.08	0.13
Baseline nicotine vaping[a]	1.61	0.52	2.69	0.58	0.32	0.85	4.29	3.48	5.11
Baseline marijuana vaping[b]	2.19	1.17	3.22	0.39	0.13	0.65	1.43	0.58	2.28
Nicotine vaping by time interaction	−0.72	−1.97	0.54	0.131	−0.61	−0.01	1.130	−2.16	−0.43
Marijuana vaping by time interaction	−0.74	−1.95	0.47	0.20	−0.49	0.09	0.32	−1.18	0.53

[a]Baseline nicotine vaping: 0= no 30-day vaping, 1= yes 30-day vaping;

[b]Baseline marijuana vaping: 0= no 30-day vaping, 1= yes 30-day vaping;

[c]Sex: 0=Male, 1=Female;

[d]Black race: 0=Not Black, 1=Black (Race was dummy coded with White race as the reference group);

[e]Other race: 0=Not other race, 1=Other race;

[f]Ethnicity: 0=Hispanic, 1=Not Hispanic;

[g]Cigarette smoking: 0=Not in the past 6 months, 1=smoked in the past 6 months;

[h] Peer vaping acceptance: 0=None, 1=Greater than or equal to 1.

Table 3.

The Effects of Changes in E-Cigarette Risk Perceptions, Perceived Benefits, and Positive Expectations before and after the EVALI Outbreak on 30-Day Vaping Behavior

	Nicotine Vaping				Marijuana Vaping			
			95% CI				95% CI	
Unadjusted model	**B**	**OR**	**Lower**	**Upper**	**B**	**OR**	**Lower**	**Upper**
(Intercept)	−2.69	0.07	0.05	0.090	−2.57	0.08	0.06	0.10
Time	0.48	1.62	1.21	2.161	0.07	1.08	0.80	1.45
Perceived benefits[a]	−0.01	0.99	0.69	1.416	0.11	1.12	0.78	1.59
Perceived risk[b]	0.48	1.61	1.12	2.313	0.39	1.48	1.03	2.12
Positive expectations[c]	0.58	1.78	1.29	2.460	0.48	1.62	1.17	2.24
Perceived benefits[a] by time interaction	−0.01	0.99	0.68	1.428	−0.07	0.94	0.63	1.40
Perceived risk[b] by time interaction	−0.33	0.72	0.49	1.048	−0.09	0.92	0.62	1.35
Positive expectations[c] by time interaction	−0.83	0.44	0.31	0.613	−0.32	0.72	0.50	1.04
			95% CI				95% CI	
Adjusted model	**B**	**OR**	**Lower**	**Upper**	**B**	**OR**	**Lower**	**Upper**
(Intercept)	−4.97	0.01	0.01	0.02	−4.37	0.01	0.01	0.03
Time	0.80	2.23	1.56	3.19	0.21	1.24	0.88	1.74
Sex[d]	−0.18	0.84	0.60	1.17	−0.33	0.72	0.53	0.98
Black race[e]	0.06	1.06	0.63	1.78	0.11	1.12	0.68	1.83
Other race[f]	−0.67	0.51	0.29	0.91	−0.14	0.87	0.55	1.38
Ethnicity[g]	−0.14	0.87	0.57	1.32	−0.31	0.73	0.50	1.07
Vaping change[h]	1.69	5.43	3.34	8.85	1.36	3.90	2.36	6.44
Cigarette smoking[i]	2.65	14.12	5.73	34.77	2.00	7.39	3.49	15.62
Peer vaping acceptance[j]	1.53	4.61	3.08	6.92	1.11	3.04	2.07	4.40
Sensation seeking	0.08	1.08	1.05	1.11	0.09	1.09	1.06	1.12
Perceived benefits[a]	−0.01	0.99	0.66	1.48	0.20	1.22	0.83	1.80
Perceived risk[b]	0.48	1.61	1.08	2.41	0.28	1.32	0.89	1.96
Positive expectations[c]	0.41	1.51	1.03	2.21	0.28	1.32	0.92	1.90
Perceived benefits by time interaction	−0.18	0.84	0.54	1.30	−0.19	0.83	0.53	1.29
Perceived risk by time interaction	−0.44	0.64	0.40	1.01	−0.09	0.92	0.59	1.42
Positive expectations by time interaction	−1.12	0.33	0.21	0.50	−0.45	0.64	0.42	0.98

[a]Perceived benefits: 0= increase or no change from baseline, 1=decrease;

[b]Perceived risk: 0= decrease or no change from baseline, 1= increase;

[c]Positive expectations: 0= increase or no change from baseline, 1=decrease;

[d] Sex: 0=Male, 1=Female;

[e] Black race: 0=Not Black, 1=Black (Race was dummy coded with White race as the reference group);

[f] Other race: 0=Not other race, 1=Other race;

[g] Ethnicity: 0=Hispanic, 1=Not Hispanic;

[h] Vaping change in model of nicotine vaping refers to change in marijuana vaping from baseline to 6-month follow-up. Vaping change in model of marijuana vaping refers to change in nicotine vaping from baseline to 6-month follow-up;

[i] Cigarette smoking: 0=Not in the past 6 months, 1=smoked in the past 6 months;

[j] Peer vaping acceptance: 0=None, 1=Greater than or equal to 1.