Original investigation

Perception of E-Cigarette Harm and Its Correlation With Use Among U.S. Adolescents

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Abstract

Introduction: U.S. adolescents increasingly use e-cigarettes. The perceived harm of e-cigarettes has not been described, nor has the correlation between harm perception and e-cigarette use been assessed. This study examines correlates of e-cigarette harm perception and use of e-cigarettes in a national survey.

Methods: We used cross-sectional nationally representative data from the 2012 National Youth Tobacco Survey ($n = 24,658$). Cross-tabulations and multivariate ordered probit and logistic regression models were employed to assess relative harm perception and e-cigarette use.

Results: Half of U.S. adolescents had heard of e-cigarettes. Of these, 13.2% (95% confidence interval [CI] = 11.7–14.9) and 4.0% (95% CI = 3.4–4.7) reported ever or currently using e-cigarettes, respectively. Of those aware of e-cigarettes, 34.2% (95% CI = 32.8–35.6) believed e-cigarettes were less harmful than cigarettes. Among those trying e-cigarettes, 71.8% (95% CI = 69.0–74.5) believed e-cigarettes were comparatively less harmful. Females and those ≥ 17 years old were more likely to perceive e-cigarettes as more harmful relative to cigarettes, while on average Whites, users of other tobacco products, and those with family members who used tobacco were more likely to perceive e-cigarettes as comparatively safer. Among cigarette-naïve e-cigarette users, use of other tobacco products and perceived harm reduction by e-cigarettes were, respectively, on average associated with 1.6 and 4.1 percentage-point increases in e-cigarette use.

Conclusions: Perception of e-cigarettes as less harmful than conventional cigarettes was associated with increased e-cigarette use, including among cigarette-naïve e-cigarette users. These findings should prompt further scientific investigation and merit attention from regulators.

Introduction

Electronic cigarettes, or e-cigarettes, are nicotine delivery devices that vaporize nicotine and other chemicals to simulate smoking a traditional cigarette. The proliferation of these products has drawn considerable consumer, media, and public health attention.¹ E-cigarettes are known to contain carcinogens, but data remain

unavailable regarding their long-term safety.^{2,3} The U.S. Food and Drug Administration (FDA) has yet to enforce a federal age-restriction policy on their purchase²; e-cigarettes thus remain widely available to adolescents despite recent local efforts to curb their use.⁴

Awareness and use of e-cigarettes has increased, both among adults and adolescents.^{3,5} Rates of adolescent e-cigarette use have doubled over a 2-year period.⁶ As many as one in five U.S. adult

cigarette smokers have tried e-cigarettes.^{3,5} While some evidence suggests that e-cigarettes may be an effective aid in smoking cessation,^{7,8} a large percentage of both adult and adolescent e-cigarette users have not used other forms of tobacco prior to using e-cigarettes.^{3,6} One recent article reported that, among U.S. adolescents, e-cigarettes appear unlikely to discourage conventional cigarette smoking.⁹ Of considerable concern, the vast majority of e-cigarette advertising contains explicit or implicit health-related claims unsupported by current scientific evidence.¹⁰

The extent to which perceived harm reduction influences adolescent e-cigarette use has thus far not been investigated. Individuals might consider e-cigarettes less harmful than cigarettes and, in turn, favor their use in lieu of cigarettes. Due to their widespread availability, cigarette-naïve adolescents—those without any prior cigarette use—may also have turned to these new products. Use by cigarette-naïve adolescents may have policy implications for this currently unregulated product since e-cigarette use by such individuals may serve as a gateway to other tobacco use. Moreover, if the perception of e-cigarettes as a safe alternative to conventional cigarette use has contributed to their increasing popularity, specific targeting of unsupported claims by industry advertisements may prove critical to curbing e-cigarette use. Of particular interest, no assessment of e-cigarette use among the cigarette-naïve population has yet been conducted.

This study attempts to address these unresolved questions. We employ nationally representative survey data to assess correlates of adolescent awareness and use of e-cigarettes, the perceived danger of e-cigarettes compared to conventional cigarettes, and correlates of e-cigarette use among cigarette-naïve adolescents. We hypothesized that perceiving e-cigarettes as less harmful than traditional cigarettes would correlate with their increased use.

Methods

Study Population

The 2012 National Youth Tobacco Survey (NYTS) provides nationally representative estimates of adolescents' tobacco-related knowledge, attitudes, and behaviors. The NYTS is a survey of middle- and high-school students conducted by the Centers for Disease Control and Prevention (CDC). Its methodology has been previously described.¹¹ Its design was approved by the CDC's institutional review board. All students enrolled in a U.S. public, secular, or nonsecular private school in grades 6–12 were eligible to be sampled. A stratified, cluster sample, designed to oversample non-Hispanic Black and Hispanic students, was employed. Participation was voluntary at both the school and student level. In 2012, the school participation rate was 80.3% and the student participation rate 91.7%. Students completed a pencil and paper, self-administered questionnaire.

Variables

E-Cigarette Use

Students' self-reported e-cigarette use was used to define dependent variables. Two variables assessing students' self-reported e-cigarette use were employed as dependent variables. Students were asked, "Which of the following tobacco products have you ever tried, even just one time?" to which they could select, "electronic cigarettes or e-cigarettes, such as Ruyan or NJOY" alongside other tobacco products. A related question asked if students used e-cigarettes on at least one of the past 30 days. Consistent with prior studies on other tobacco

products,¹¹ this latter question serves as a proxy for current e-cigarette use.

Other Variables

Independent variables included students' demographic information and their use and beliefs about tobacco as well as their plan for smoking cessation. Demographic variables included students' sex, age, and ethnicity. Ethnicity was categorized by Hispanic status; non-Hispanics were further classified as Black, White, Asian, or those of another or multiple races.

Tobacco-related covariates included whether any other individual in the students' home used tobacco products and whether the student had smoked a cigarette on at least one of the past 30 days. Students were also queried as to whether they had used alternative tobacco products including cigars, dip, pipes, hookah, snus, or dissolvable tobacco products within the past 30 days; a variable indicating use of any of these products was employed in the analyses. A variable indicating that students reported being counseled by a family member to avoid tobacco products within the past year was also included.

Adolescents' beliefs about the harms of tobacco were also assessed. Students were asked how strongly they agreed with the statement that, "All tobacco products are dangerous," to which they could respond on a 4-point Likert scale that they "strongly agree," "agree," "disagree," or "strongly disagree." Students were also queried as to the specific potential harms of e-cigarettes, being asked whether they believed that, "electronic cigarettes, or e-cigarettes, such as Ruyan or NJOY are less harmful, equally harmful, or more harmful than regular cigarettes?" Students could select one of these options, or that they had, "never heard of electronic cigarettes or e-cigarettes" or "[didn't] know enough about these products."

Statistical Methods

The NYTS employs a stratified, multistage sample designed to generate nationally representative estimates.¹¹ Consequently, all analyses were weighted to adjust for nonresponse and the probability of selection and to match the sample's sociodemographic characteristics with those of U.S. middle- and high-school students. Standard errors were calculated by Taylor series linearization to account for clustering of responses.¹² Cross-tabulations were assessed and multivariable ordered probit and logistic analyses were conducted using Stata 11.2. Average marginal effects, estimating the average change of altering each covariate among the study population, were reported. Collinearity of variables used in the analyses was assessed using variance inflation factors¹³; no evidence of concerning multicollinearity was found. In addition, following previous literature, complete case selection was used in lieu of imputation procedures.⁹

Results

Data from 24,658 respondents, corresponding to 27 million adolescents nationally, were assessed. Table 1 displays the characteristics of the study's sample as well as the prevalence of awareness about and use of e-cigarettes among different demographic groups. Overall, 50.3% (95% confidence interval [CI] = 33.0–37.9) of all adolescents had heard of e-cigarettes. Awareness increased with age, with 35.4% (95% CI = 33.0–37.9) of those ≤12 years old and 59.8% (95% CI = 56.4–63.0) of those ≥17 years old having heard of e-cigarettes. In addition, among those individuals who had heard of e-cigarettes, rates of actual use, both having ever used

Table 1. Sample Characteristics, and Awareness and Use of E-Cigarettes

	No. (%) ^a	Prevalence of e-cigarette awareness and use, % (95% CI) ^b				
		Among those aware of e-cigarettes				
		Aware	Ever	Current	Ever	Current
Overall	24,644	50.3 (48.5, 52.0)	6.8 (5.9, 7.7)	2.1 (1.8, 2.5)	13.2 (11.7, 14.9)	4.0 (3.4, 4.7)
Sex						
Male	12,369 (51.1)	51.9 (50.0, 53.8)	8.1 (7.0, 9.3)	2.8 (2.2, 3.5)	15.1 (13.2, 17.3)	5.0 (4.0, 6.2)
Female	12,275 (48.9)	48.6 (46.6, 50.6)	5.5 (4.7, 6.4)	1.4 (1.2, 1.7)	11.2 (9.6, 12.9)	2.9 (2.4, 3.5)
Race/ethnicity						
Non-Hispanic White	11,814 (53.9)	58.6 (56.5, 60.7)	8.1 (7.0, 9.5)	2.3 (1.9, 2.8)	13.7 (11.9, 15.7)	3.9 (3.2, 4.7)
Non-Hispanic Black	3,114 (13.9)	32.9 (30.0, 35.9)	3.3 (2.6, 4.1)	1.2 (0.7, 1.8)	9.1 (7.0, 11.8)	2.6 (1.7, 4.0)
Hispanic	5,733 (21.7)	41.2 (38.3, 44.0)	6.2 (5.0, 7.6)	2.4 (1.9, 3.2)	14.8 (12.2, 17.7)	5.4 (4.2, 7.0)
Non-Hispanic Asian	1,106 (3.7)	38.9 (32.6, 45.5)	2.3 (1.2, 4.4)	0.9 (0.3, 2.8)	5.6 (3.0, 10.2)	2.0 (0.6, 6.8)
Other/multiple	2,105 (6.9)	58.4 (55.0, 52.4)	8.1 (6.5, 10.1)	2.5 (1.7, 3.5)	13.8 (11.1, 17.1)	4.1 (2.8, 5.8)
Age						
≤ 12	5,037 (19.8)	35.4 (33.0, 37.9)	1.5 (1.1, 2.0)	0.7 (0.4, 1.1)	4.1 (3.1, 5.5)	1.8 (1.1, 3.0)
13	3,995 (14.6)	43.9 (41.0, 46.9)	2.8 (2.2, 3.5)	1.1 (0.8, 1.6)	6.1 (4.7, 7.8)	2.4 (1.5, 3.6)
14	3,595 (14.2)	51.2 (48.6, 43.9)	5.4 (4.2, 6.8)	1.8 (1.2, 2.7)	10.1 (7.7, 13.2)	3.1 (2.0, 5.0)
15	3,185 (14.7)	55.1 (51.8, 58.3)	8.0 (6.5, 9.9)	2.4 (1.7, 3.3)	14.1 (11.6, 17.0)	4.2 (3.1, 5.7)
16	3,245 (14.5)	56.3 (52.7, 59.9)	9.0 (7.4, 11.0)	2.8 (2.0, 3.7)	15.7 (13.1, 18.7)	4.8 (3.5, 6.4)
≥ 17	5,498 (22.3)	59.8 (56.4, 63.0)	6.8 (6.0, 7.8)	3.6 (2.9, 4.4)	20.9 (18.5, 23.7)	5.7 (4.7, 6.9)

^aUnweighted *n*, with weighted population-weighted column percentages displayed in parentheses.

^bPopulation-weighted percentages are displayed, with 95% CIs calculated by Taylor series linearization to account for the complex survey design.

e-cigarettes and current use, increased with age. Among those aged ≤12 years old, only 4.1% (95% CI = 3.1–5.5) had ever tried e-cigarettes and 1.8% (95% CI = 1.1–3.0) had recently used e-cigarettes while, among those ≥17 years old, 20.9% (95% CI = 18.5–23.7) and 5.7% (95% CI = 4.7–6.9) had ever and recently used e-cigarettes, respectively.

No difference in e-cigarette awareness was noted by sex, but awareness of e-cigarettes did differ by ethnicity. Non-Hispanic Blacks were least familiar with e-cigarettes (32.9%; 95% CI = 30.0–35.9), while non-Hispanic Whites were most likely to have heard of e-cigarettes (58.9%; 95% CI = 56.5–60.7). Despite no difference between the sexes with respect to their awareness of e-cigarettes, males (8.1%; 95% CI = 7.0–9.3) were more likely than females (5.5%; 95% CI = 4.7–6.4) to have tried or be currently using e-cigarettes. Rates of e-cigarette use also varied by ethnicity though percentage-point differences between ethnic groups were less dramatic after accounting for differences in e-cigarette awareness. Among those who had heard of e-cigarettes, Hispanics were most likely (14.8%; 95% CI = 12.2–17.7) and Asians least likely, respectively, (5.6%; 95% CI = 3.0–10.2) to have ever tried e-cigarettes. These ethnic groups were also the most and least likely, respectively, to currently use e-cigarettes. Use of e-cigarettes also correlated with use of other alternative tobacco products ([Supplementary Table 1](#)).

[Table 2](#) examines the association between harm perception and e-cigarette use among individuals who had heard of e-cigarettes. Notably, a plurality (45.0%; 95% CI = 43.8–46.3) of adolescents felt they were unable to assess the relative harm of e-cigarettes compared to cigarettes. In nearly every subgroup examined, the perception that e-cigarettes were less harmful than cigarettes, compared to equally or more harmful, was the second most frequently voiced opinion. Of all

adolescents, 34.2% (95% CI = 32.8–35.6) considered e-cigarettes to be less harmful than traditional cigarettes. Differences in harm perception were noted by sex. Males (38.8%; 95% CI = 37.2–40.4) were more likely than females (29.4%; 95% CI = 27.8–31.1) to perceive e-cigarettes as less harmful than cigarettes. Harm perception changed only trivially with age, with older individuals less uncertain and more likely to opine that e-cigarettes and cigarettes were similarly dangerous.

Most notably different with respect to harm perception, however, was that users of e-cigarettes were much more likely to perceive their use as less dangerous than traditional cigarettes. Those who had ever used an e-cigarette (71.8%; 95% CI = 69.0–74.5) were more likely than those who had not (31.0%; 95% CI = 29.8–32.3) to report e-cigarettes were less harmful than cigarettes. Similar findings were noted among those who had recently used an e-cigarette (73.8%; 95% CI = 68.5–78.5) compared to those who had not (33.1%; 95% CI = 31.8–34.4). As regards harm perception, some ethnic differences were also noted. Of all ethnic groups, Non-Hispanic Asians were most uncertain, with 53.3% (95% CI = 48.3–58.2) undecided about the potential harm of e-cigarettes relative to cigarettes. Non-Hispanic Whites (37.4%; 95% CI = 35.7–39.0) and those of another or multiple races (36.4%; 95% CI = 33.1–39.8) were, by contrast, those ethnic groups with the highest rates of individuals who believed e-cigarettes were comparatively less harmful.

[Table 3](#) displays results from a multivariable ordered probit regression model assessing correlates of perceiving e-cigarettes as comparatively more harmful than conventional cigarettes. Individuals using alternative tobacco products were, on average, less likely to perceive that e-cigarettes were harmful; on average, such individuals were 0.8 percentage-points less likely than those who did not use alternative tobacco products to perceive e-cigarettes as

Table 2. Perceived Harm of E-Cigarettes^a

	Harm of e-cigarettes, compared to cigarettes, % (95% CI) ^b			
	Less	Equally	More	Don't know
Overall	34.2 (32.8, 35.6)	17.5 (16.7, 18.4)	3.2 (2.8, 3.6)	45.0 (43.8, 46.3)
Sex				
Male	38.8 (37.2, 40.4)	14.9 (13.9, 15.8)	3.5 (3.0, 4.0)	42.9 (41.5, 44.4)
Female	29.4 (27.8, 31.1)	20.4 (19.1, 21.7)	2.9 (2.5, 3.4)	47.3 (45.6, 48.9)
Race/ethnicity				
Non-Hispanic White	37.4 (35.7, 39.0)	17.8 (16.7, 19.0)	2.0 (1.7, 2.4)	42.8 (41.3, 44.3)
Non-Hispanic Black	30.6 (28.4, 32.9)	14.7 (13.0, 16.4)	5.8 (4.6, 7.3)	49.0 (46.4, 51.5)
Hispanic	29.3 (26.9, 31.8)	18.1 (16.6, 19.8)	4.3 (3.6, 5.3)	48.2 (45.6, 50.9)
Non-Hispanic Asian	26.1 (22.9, 29.5)	17.2 (14.5, 20.2)	3.5 (2.2, 5.6)	53.3 (48.3, 58.2)
Other/multiple	36.4 (33.1, 39.8)	19.2 (17.0, 21.7)	3.3 (2.3, 4.7)	41.1 (37.8, 44.5)
Age				
≤ 12	31.2 (28.4, 33.0)	14.9 (13.3, 16.8)	3.6 (2.9, 4.5)	50.3 (48.3, 52.3)
13	34.6 (32.01, 37.1)	17.0 (15.2, 19.1)	3.2 (2.4, 4.1)	45.3 (43.0, 47.6)
14	35.3 (32.7, 38.0)	16.7 (14.8, 18.7)	3.3 (2.3, 4.7)	44.8 (42.6, 46.9)
15	34.9 (32.1, 37.9)	17.8 (16.1, 19.5)	3.7 (2.8, 4.9)	43.6 (40.9, 46.3)
16	36.1 (33.8, 38.5)	19.3 (17.2, 21.6)	2.6 (2.0, 3.3)	42.0 (39.9, 44.1)
≥ 17	33.9 (31.6, 36.3)	19.2 (17.9, 20.5)	3.0 (2.4, 3.7)	44.0 (41.6, 46.4)
E-cigarette use, ever				
No	31.0 (29.8, 32.3)	18.0 (17.2, 18.9)	3.1 (2.7, 3.6)	47.9 (46.7, 49.0)
Yes	71.8 (69.0, 74.5)	12.5 (10.7, 14.6)	4.2 (3.1, 5.5)	11.5 (9.5, 13.9)
E-cigarette use, current				
No	33.1 (31.8, 34.4)	17.7 (16.9, 18.6)	3.1 (2.7, 3.6)	46.1 (44.9, 47.3)
Yes	73.8 (68.5, 78.5)	12.1 (9.3, 15.5)	5.0 (3.0, 8.2)	9.2 (5.8, 14.2)

^aIncludes individuals who had “ever heard of...Electronic cigarettes or E-cigarettes, such as Ruyan or NJOY” from a list of alternative tobacco products.

^bWeighted row percentages are displayed, with 95% CIs calculated by Taylor series linearization to account for the complex survey design.

more dangerous than conventional cigarettes. Use of cigarettes was estimated to have a similar relationship, though this result was of borderline statistical significance. All else equal, females were more likely to perceive e-cigarettes as harmful than males; on average, females were 2.6 percentage points more likely than males to say that e-cigarettes were more harmful than cigarettes. Perception of increased harm from e-cigarettes also increased at the highest age bracket, with those ≥17 years old on average 1.5 percentage points more likely to indicate e-cigarettes were more harmful than conventional cigarettes. Of note, those with a family member who used tobacco were less likely to perceive e-cigarettes as harmful (odds ratio 0.88, 95% CI = 0.83–0.93).

Results from a multivariable logistic regression analysis assessing e-cigarette use among cigarette-naïve adolescents are shown in Table 4. Perception of e-cigarettes as less harmful than cigarettes was associated with an increased likelihood of having ever used e-cigarettes. On average, such beliefs were associated with a 1.6 percentage-point increase in e-cigarette use. Having ever used other tobacco products including cigars, dip, pipes, hookah, snus, or dissolvable tobacco products was associated with a 4.1 percentage-point increase in e-cigarette use.

Discussion

Billions of dollars are at stake in the controversy over e-cigarettes, with estimates predicting that e-cigarette sales will quadruple between 2011 and 2014¹⁴ and that, within a decade, e-cigarette sales may surpass those of cigarettes.⁷ The discourse surrounding e-cigarettes, including their potential use as a smoking cessation tool

and potential harm as an unregulated nicotine source, has thus far been insufficiently informed by how these products are being used in real time. Prior research has noted that e-cigarette advertising makes frequent health-related claims¹⁰ and often targets adolescents.¹⁵ This analysis marks the first effort of which we are aware to consider the perception of e-cigarette's harm relative to cigarettes as well as correlates of e-cigarette use in cigarette-naïve adolescents. Our results show that, nationally, a plurality of adolescents remained unable to assess the potential danger of e-cigarettes compared to conventional cigarettes. We report that those who perceived e-cigarettes as less harmful than conventional cigarettes were more likely to use e-cigarettes and, conversely, that those who use e-cigarettes perceive them as less dangerous. While intuitive, these results underscore mounting concern surrounding the suspect advertising practices of e-cigarette manufacturers as well as the underlying motivations of adolescents who access this largely unregulated tobacco source.

Some specific findings merit attention. Roughly half of all adolescents, including over a third of those ≤12 years old, had heard of e-cigarettes. These rates of e-cigarette awareness were broadly comparable to reported rates among adults within the past few years.³ Awareness of e-cigarettes was similar between sexes but did differ by ethnicity. Non-Hispanic Blacks were least likely to have heard of e-cigarettes, while non-Hispanic Whites and those of another or multiple races were most likely to have heard of e-cigarettes. This finding is consistent with previous research examining e-cigarette awareness in adults, which has also noted this ethnic gap.³ Advertising practices of e-cigarettes companies may also play a role in this ethnic awareness gap, though prior research suggests e-cigarettes to be targeted toward White males.¹⁵ Some have previously observed

Table 3. Multivariable Ordered Probit Regression Assessing E-Cigarette Harm Perception^a

	OR (95% CI) ^b	Average marginal effects predicting e-cigarettes are more harmful ^c		
		Prob. (%)	95% CI	<i>p</i>
Ever use of cigarettes				
No	1.00		Reference	
Yes	0.92 (0.85, 1.01)	−0.9	(−1.8, 0.1)	.07
Ever use of other tobacco products ^d				
No	1.00		Reference	
Yes	0.93 (0.86, 1.00)	−0.8	(−1.5, −0.1)	.03
All tobacco products are dangerous				
Strongly agree	1.00		Reference	
Agree	0.76 (0.70, 0.82)	−2.8	(−3.5, −2.1)	<.001
Disagree	0.75 (0.65, 0.88)	−2.8	(−4.1, −1.5)	<.001
Strongly disagree	1.06 (0.91, 1.23)	0.7	(−1.3, 2.7)	.48
Sex				
Male	1.00		Reference	
Female	1.27 (1.20, 1.34)	2.6	(2.0, 3.2)	<.001
Age				
≤ 12	1.00		Reference	
13	1.01 (0.89, 1.14)	0.1	(−1.2, 1.4)	.89
14	0.97 (0.87, 1.10)	−0.3	(−1.4, 0.9)	.67
15	1.08 (0.96, 1.20)	0.8	(−0.4, 2.0)	.20
16	1.05 (0.95, 1.17)	0.5	(−0.6, 1.7)	.33
≥ 17	1.14 (1.03, 1.26)	1.5	(0.4, 2.6)	.01
Race/ethnicity				
Non-Hispanic White	1.00		Reference	
Non-Hispanic Black	1.24 (1.13, 1.36)	2.4	(1.2, 3.6)	<.001
Hispanic	1.28 (1.17, 1.40)	2.8	(1.7, 4.0)	<.001
Non-Hispanic Asian	1.24 (1.11, 1.38)	2.4	(1.0, 3.8)	.001
Other/multiple	1.11 (0.97, 1.26)	1.0	(−0.4, 2.4)	.15
Family member uses tobacco				
No	1.00		Reference	
Yes	0.88 (0.83, 0.93)	−1.4	(−1.9, −0.8)	<.001
Parent/guardian discussed not using a tobacco product, past 12 months				
No	1.00		Reference	
Yes	0.99 (0.93, 1.06)	−0.1	(−0.8, 0.6)	.80
Cut 1	0.36 (0.26, 0.45)			
Cut 2	1.67 (1.59, 1.76)			

^aModel assesses increasing levels of harm perception of e-cigarettes relative to conventional cigarettes. This includes individuals who responded to the question that “electronic cigarettes or e-cigarettes, such as Ruyan or NJOY are (less harmful, equally harmful, or more harmful) than regular cigarettes?” and selected one of those three responses; it excludes individuals who reported that they, “didn’t know enough about these products” to answer and those that had, “never heard of electronic cigarettes or e-cigarettes.”

^bOdds ratios (ORs) displayed reflect estimates from the weighted multivariate ordered probit model in which all listed covariates are included, with 95% confidence intervals (CI) calculated by Taylor series linearization to account for the complex survey design.

^cAverage marginal effects estimate the average change of altering each covariate (e.g., having used other tobacco products compared to not having used other tobacco products) among the study population, estimating the likelihood that an individual perceived e-cigarettes as *more* harmful than conventional cigarettes.

^dOther tobacco use includes use of cigars, dip, pipes, hookah, snus, or dissolvable tobacco products.

that adolescents may be at particularly high risk for e-cigarette use due to the targeted online advertising of e-cigarettes,^{15,16} though we were unable to assess the importance of e-cigarette advertising in this sample. Of note in our study, is that males were less likely than females to perceive e-cigarettes as comparatively more dangerous. This may stem in part from industry advertising directed toward this demographic.¹⁵

Differences in the harm perception of e-cigarettes appear to belie their use. Many adolescents felt unable to assess the comparative harms and benefits of using e-cigarettes in lieu of cigarettes, which may reflect continued confusion as to their risks within the public and scientific community. Yet many, roughly one third of adolescents, perceived e-cigarettes as less harmful than cigarettes. Notably,

few e-cigarette users were unsure regarding their perception of e-cigarette safety. Nearly three fourths of these individuals perceived e-cigarettes as less harmful than cigarettes. The association between harm perception and use was particularly notable among cigarette-naïve individuals, where, on average, the perception of e-cigarettes as less harmful than cigarettes was associated with a 1.6 percentage-point increase in e-cigarette use. Such a link between perceived harm reduction and e-cigarette use is plausible and intuitive. Yet the extent to which this link exists remains undetermined, and the rise of dedicated e-cigarette use requires further elucidation as to the potential risks and benefits of e-cigarette use in order to assess what recommendations ought to be promulgated regarding e-cigarettes’ use in harm reduction and smoking cessation.

Table 4. Multivariable Logistic Regression Assessing Correlates of Ever Using E-Cigarettes Among Cigarette-Naïve Adolescents^a

	OR (95% CI) ^b	Average Marginal Effects ^c		
		Prob. (%)	95% CI	<i>p</i>
Compared to cigarettes, e-cigarettes are...				
Less harmful	3.60 (0.83, 15.7)	1.6	(0.5, 2.6)	.01
Equally harmful	0.46 (0.09, 2.34)	0.3	(-1.3, 0.6)	.47
More harmful	1.00		Reference	
I don't know enough about these products	0.52 (0.11, 2.47)	-0.3	(-1.2, 0.6)	.52
Ever use of other tobacco products ^d				
No	1.00		Reference	
Yes	11.45 (6.96, 18.8)	4.1	(2.6, 5.7)	<.001
All tobacco products are dangerous				
Strongly agree	1.00		Reference	
Agree	1.23 (0.77, 1.98)	0.2	(-0.3, 0.7)	.39
Disagree	0.64 (0.23, 1.75)	-0.3	(-1.0, 0.3)	.32
Strongly disagree	1.31 (0.48, 3.57)	0.3	(-0.8, 1.3)	.63
Sex				
Male	1.00		Reference	
Female	1.12 (0.74, 1.69)	0.1	(-0.3, 0.5)	.61
Age				
≤ 12	1.00		Reference	
13	0.81 (0.38, 1.71)	-0.2	(-0.7, 0.4)	.57
14	1.30 (0.68, 2.47)	0.2	(-0.4, 0.8)	.44
15	1.41 (0.66, 2.99)	0.3	(-0.4, 1.1)	.40
16	1.08 (0.55, 2.11)	0.1	(-0.5, 0.6)	.83
≥ 17	1.34 (0.75, 2.38)	0.3	(-0.2, 0.8)	.31
Race/ethnicity				
Non-Hispanic White	1.00		Reference	
Non-Hispanic Black	0.71 (0.39, 1.28)	-0.3	(-0.7, 0.1)	.21
Hispanic	1.13 (0.67, 1.92)	0.1	(-0.4, 0.6)	.66
Non-Hispanic Asian	1.31 (0.45, 3.78)	0.3	(-0.8, 1.4)	.65
Other/multiple	1.90 (0.89, 4.08)	0.8	(-0.3, 1.9)	.18
Family member uses tobacco				
No	1.00		Reference	
Yes	1.19 (0.69, 2.04)	0.2	(-0.3, 0.7)	.52
Parent/guardian discussed not using a tobacco product, past 12 months				
No	1.00		Reference	
Yes	1.10 (0.71, 1.72)	0.0	(-0.3, 0.4)	.66

^aIncludes cigarette-naïve adolescents, those without any prior cigarette use, who had heard of e-cigarettes.

^bOdds ratios (ORs) displayed reflect estimates from the weighted multivariate model in which all listed covariates are included, with 95% confidence intervals (CI) calculated by Taylor series linearization to account for the complex survey design.

^cAverage marginal effects estimate the average change of altering each covariate (e.g., having used other tobacco products compared to not having used other tobacco products) among the study population.

^dOther tobacco use includes use of cigars, dip, pipes, hookah, snus, or dissolvable tobacco products.

No definitive data yet exist regarding the long-term safety of e-cigarette use. Nonetheless, the FDA has reported that e-cigarette cartridges and solutions contain known carcinogens including nitrosamines and diethylene glycol.¹⁷ Further, potentially harmful trace metals such as lead, chromium, and nickel have also been found in e-cigarette aerosol in levels comparable to cigarette smoke.¹⁸ The physical effects of “vaping,” or inhaling e-cigarette vapor, remain debated. While some studies have shown no change to basic pulmonary parameters,¹⁹ others have suggested increases in peripheral airway resistance and reductions in the ratio of the forced expiratory volume in one second to forced vital capacity (i.e., FEV₁/FVC ratio).²⁰ Given ongoing concern regarding the potential adverse effects of e-cigarette use, in the absence of their use as a smoking cessation tool, e-cigarettes pose a potential respiratory health threat. This is especially concerning since early adolescent adoption of

e-cigarettes may, as with cigarettes,²¹ develop into longer term use. Industry's specific targeting of adolescents¹⁵ with unsupported health-related claims¹⁰—and their apparent success in convincing individuals that e-cigarettes are a safer alternative—presents a concerning picture unaddressed by current regulatory policies.

An understanding of the limitations of this analysis is important, however. Data are cross-sectional and cannot be used to infer causality. In addition, data rely on self-report, which may have biased results in an unknown direction. Socioeconomic influences, including family structure, poverty status, rural status, and parental education, were unavailable in the dataset analyzed and might have influenced the observed associations in an as yet undescribed manner.

Yet significant strengths of our analysis merit attention. This study employs a large, nationally representative sample to draw inferences about the current state of adolescent e-cigarette use.

It employs appropriate statistical techniques, including ordinal probit regression, that best suit the form of the data, while reporting average marginal effects to provide readers' real-world estimates of the magnitude of the estimated associations. Importantly, it assesses a question of critical policy import, how the perceived safety of e-cigarettes influences U.S. adolescents' use of this product.

Our results, the first of which we aware to consider this, suggest that adolescents who perceive e-cigarettes as less harmful than cigarettes are more likely to use them and that, conversely, e-cigarette users believe their products are comparatively safer than conventional cigarettes. Moreover, there appear to be numerous cigarette-naïve adolescents who use e-cigarettes alongside other alternative tobacco products. While more research is required to further assess the relationship between adolescent e-cigarette and other tobacco use, our findings merit further consideration from research and policy perspectives as to the ongoing lack of e-cigarette regulation.

Supplementary Material

Supplementary Table 1 can be found online at <http://www.ntr.oxfordjournals.org>

Declaration of Interests

None declared.

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