

Original investigation

Intentions to Smoke Cigarettes Among Never-Smoking US Middle and High School Electronic Cigarette Users: National Youth Tobacco Survey, 2011–2013

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Abstract

Introduction: Electronic cigarette (e-cigarette) use is increasing rapidly, and the impact on youth is unknown. We assessed associations between e-cigarette use and smoking intentions among US youth who had never smoked conventional cigarettes.

Methods: We analyzed data from the nationally representative 2011, 2012, and 2013 National Youth Tobacco Surveys of students in grades 6–12. Youth reporting they would definitely not smoke in the next year or if offered a cigarette by a friend were defined as not having an intention to smoke; all others were classified as having positive intention to smoke conventional cigarettes. Demographics, pro-tobacco advertisement exposure, ever use of e-cigarettes, and ever use of other combustibles (cigars, hookah, bidis, kreteks, and pipes) and noncombustibles (chewing tobacco, snuff, dip, snus, and dissolvables) were included in multivariate analyses that assessed associations with smoking intentions among never-cigarette-smoking youth.

Results: Between 2011 and 2013, the number of never-smoking youth who used e-cigarettes increased 3-fold, from 79,000 to more than 263,000. Intention to smoke conventional cigarettes was 43.9% among ever e-cigarette users and 21.5% among never users. Ever e-cigarette users had higher adjusted odds for having smoking intentions than never users (adjusted odds ratio = 1.70, 95% confidence interval = 1.24–2.32). Those who ever used other combustibles, ever used noncombustibles, or reported pro-tobacco advertisement exposure also had increased odds for smoking intentions.

Conclusion: In 2013, more than a quarter million never-smoking youth used e-cigarettes. E-cigarette use is associated with increased intentions to smoke cigarettes, and enhanced prevention efforts for youth are important for all forms of tobacco, including e-cigarettes.

Introduction

The impact of new and emerging products, including electronic cigarettes (e-cigarettes) and other electronic nicotine delivery systems (ENDS),¹ on youth use of conventional combusted tobacco products is unknown.^{2,3} Surveillance data on ENDS use and related behaviors remain scarce, and there is much speculation about the net public health impact of ENDS at the population level.³⁻⁵ ENDS are being marketed heavily, using both traditional (e.g. television) and digital marketing strategies.⁶⁻¹⁰ ENDS use is increasing rapidly among both adults and youth¹¹⁻¹³ with ever e-cigarette use doubling from 3.3% to 6.8% between 2011 and 2012 among middle and high school students.¹¹

Preventing youth initiation and transition to established smoking are critical and well-established public health goals.^{14,15} Cigarette smoking remains the leading cause of preventable disease and death in the United States, and more than 80% of adult smokers begin smoking by 18 years of age.¹⁶ While cigarette smoking rates have declined in recent decades in the United States, an estimated 5.6 million American children alive today will die prematurely from a smoking-related illness unless smoking rates decline much more.¹⁵ Evidence-based strategies, including mass media campaigns, price increases, and changes in smoke-free policies and norms have been effective in reducing the initiation, prevalence, and intensity of youth smoking in settings where they have been comprehensively implemented.^{16,17} Full implementation of comprehensive tobacco control programs, coupled with FDA regulation of tobacco products,¹⁸ would be expected to reduce youth tobacco use further. However, implementation has been limited and uneven across states and communities, and an estimated 3000 youth start smoking cigarettes every day.¹⁶

The use of cigarettes and other combusted tobacco products has been the principle cause of the 20 million tobacco-related deaths that have occurred in the United States since 1964.¹⁵ In theory, if ENDS (including e-cigarettes) or other nicotine delivery devices cause less harm than cigarettes and other combustible tobacco products, their use by current conventional tobacco smokers could reduce disease and death, if smokers switch completely and end all combustible product use.¹⁹ ENDS are more likely to be beneficial if their use is concurrent with interventions that rapidly reduce the appeal, accessibility, promotion, and use of cigarettes.¹⁵ However, if conventional tobacco smokers become concurrent users of ENDS and combustible products (dual users) rather than quitting both products or completely substituting ENDS for combustible products, or if ENDS leads to initiation of nicotine use among nonusers and relapse among former smokers, then ENDS could result in net public health harm to the US population.¹⁵ ENDS, which contain nicotine, may be particularly harmful to youth, because ENDS and nicotine exposure could have long-term negative consequences on adolescent brain development,¹⁵ can result in nicotine addiction,²⁰ and have the potential to lead youth to use other forms of tobacco products.²

Prior research has examined youth experimentation and progression to cigarette smoking.¹⁵ Measures of intention to smoke cigarettes have been validated²¹ and have been shown to predict future cigarette smoking, irrespective of previous smoking behavior.^{22,23} Additionally, research has identified other predictors of future cigarette use, including exposure to pro-tobacco marketing and promotion, living with a smoker, parental smoking, having friends who smoke, and performing poorly in school.²⁴⁻²⁶ However, additional research will be useful to understand predictors of intention to use cigarettes, given the changing tobacco product landscape with the advent of ENDS.

To address this gap and to help inform decisions regarding public health policy and practice, we analyzed US nationally representative data from the 2011, 2012, and 2013 National Youth Tobacco

Surveys (NYTS) to determine if e-cigarette use is associated with elevated intentions to smoke conventional cigarettes among middle and high school students who have never smoked cigarettes.

Methods

Data Source

The NYTS is a nationally representative, self-administered survey of US students enrolled in grades 6–12 in both public and private schools. Details of the NYTS methodology are available elsewhere (http://www.cdc.gov/TOBACCO/data_statistics/surveys/NYTS/index.htm). In brief, NYTS uses a stratified, three-stage cluster sample design to produce a nationally representative sample of middle school and high school students in the US. Sampling procedures are probabilistic and conducted without replacement at all stages, and entail selection of Primary Sampling Units (PSUs) within each stratum, schools within each selected PSU, and, lastly, classes within each selected school. Participation is voluntary for schools and students and anonymous at the student level. Participants complete the self-administered, scannable questionnaire booklet via pencil and paper.

Sample

We analyzed data from the 2011, 2012, and 2013 NYTS. Overall NYTS participation rates, representing the product of the school-level and student-level participation rates, were 67.8% in 2013 with 18,406 completed student questionnaires, 73.6% in 2012, with 24,658 completed student questionnaires, and 72.7% in 2011, with 18,866 completed student questionnaires.

Measures

For all of the definitions below, specific questionnaire wording is available at (http://www.cdc.gov/TOBACCO/data_statistics/surveys/NYTS/index.htm).

Never Cigarette Smokers

Students who selected “no” to the question “Have you ever tried cigarette smoking, even one or two puffs?” were considered never cigarette smokers. Those who selected “yes” were considered ever cigarette smokers.

Intention to Use Cigarettes Among Never Cigarette Smokers

Drawing from prior research,²¹⁻²³ we defined intention to use cigarettes among never cigarette smokers as lacking a firm commitment not to smoke, using a composite measure of the two questions that were available for all three survey years: “Do you think you will smoke a cigarette in the next year?” and “If one of your best friends were to offer you a cigarette, would you smoke it?” Response options included: “definitely yes,” “probably yes,” “probably not,” and “definitely not.” Those who responded “definitely not” to both intentions questions were classified as not having intentions; otherwise, respondents were classified as having intentions. This definition was also applied to 0.45% of the total sample who had a missing response to one of the two intentions questions and were classified as having intentions. Respondents with missing responses to both intentions questions represented 0.35% of the sample and were excluded. In addition, we conducted analyses using two alternative definitions. One used only a single question (smoking in the next year) to define intentions and the second only classified respondents as having intentions if they responded “definitely yes” or “probably yes” to the two intentions questions.

Ever Electronic Cigarette Users

Students who selected “Electronic Cigarettes or E-cigarettes, such as Ruyan or NJOY” to the question “Which of the following products have you ever tried, even just one time?” were considered ever e-cigarette users.

Current Electronic Cigarette Users

Students who selected “Electronic Cigarettes or E-cigarettes, such as Ruyan or NJOY” to the question “In the past 30 days, which of the following products have you used on at least one day?” were considered to be current e-cigarette users.

Ever Other Combustible User

Other combustible tobacco products assessed included: cigars, hookah, bidis, kreteks, and pipes. Students who reported ever use of any of these other combustible products were considered to be ever other combustible product users.

Current Other Combustible User

Students who reported using any of the other combustible products on at least one day in the last 30 days were defined as current other combustible users.

Ever Noncombustible Users

Noncombustible products included chewing tobacco, snuff, dip, snus, and dissolvables. Students who reported ever use of any of these noncombustible products were defined as ever noncombustible users.

Current Noncombustible Users

Students who reported using any of the noncombustible products on at least one day in the last 30 days were defined as current noncombustible users.

Pro-Tobacco Exposure

Pro-tobacco advertisement exposures were assessed for the following media sources: internet, magazine/newspaper, retail, and television/movies. For each source, respondents were asked “...how often do you see ads or promotions for cigarettes or other tobacco products?,” with the beginning of the question describing each particular media source. Respondents who answered “I do not use/read/go/watch,” “never,” or “rarely” were considered not exposed to that source; otherwise, those who answered that they had seen pro-tobacco advertisements “sometimes,” “most of the time,” or “always” were considered exposed to pro-tobacco advertisement through that source. The total number of distinct sources of pro-tobacco advertisement exposure reported by each student was summed to create a cumulative exposure measure and categorized (none, 1–2, 3–4).

Respondent Characteristics

Student characteristics included: sex (male or female), school level (middle or high), presence of a tobacco user in the household (yes or no), and race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, or Hispanic). The ‘non-Hispanic other’ category included respondents who were non-Hispanic and Asian, Native American or Alaska Native, Hawaiian or Pacific Islander, or multiple races. Additionally, survey year (2011, 2012, or 2013) was assessed.

Household Member Uses Tobacco

Students who responded and selected anything other than “no one who lives with me now uses any form of tobacco” to the question “Does anyone who lives with you now...?” were considered to live with a household member that uses tobacco.

School

Students who reported being in 6th, 7th, or 8th grades were considered to be in middle school. Those who reported being in 9th, 10th, 11th, or 12th grades were considered to be in high school.

Analysis

To augment sample size of ever and current electronic cigarette users who had never smoked cigarettes for the intention to smoke analysis, we pooled data from the 2011, 2012, and 2013 NYTS surveys. Data were adjusted for nonresponse and weighted to be representative of the US middle and high school student population; 95% confidence intervals (CIs) were calculated to account for the complex survey design. All analyses were performed using SAS-Callable SUDAAN (v. 11.0.0).

We assessed respondent characteristics and prevalence of ever and current use of e-cigarette use among never cigarette smokers ($n = 43,873$). Characteristics and exposures were assessed for never smokers with and without smoking intentions. Chi-squared tests were used to compare differences across these two groups. Multivariate logistic regression models were fit for never cigarette smokers to assess correlates of intention to smoke ($p < .05$). Different models were used to assess current and ever use of e-cigarettes. Covariates included sex, race/ethnicity, school level, number of distinct sources of pro-tobacco advertisement exposure, presence of a tobacco user in the household, and survey year. Variables for ever and current other combustible use and noncombustible use were included in the ever and current models, respectively. In addition, we fit models with categorical (ever use, current use, and never use) variables for combustible, noncombustible and e-cigarette use and models using two other definitions for smoking intentions. One definition only classified respondents as having intentions if they responded “definitely yes” or “probably yes” to the two intentions questions and the other used only a single question to define intentions (i.e. smoking in the next year). For all models, variables were entered into the model simultaneously and no model reduction procedures were performed.

Results

E-Cigarette Use

Overall, 73.0% (95% CI = 71.6–74.3) of youth ($n = 43,873$) were never cigarette smokers. Of all youth, 6.1% (95% CI = 5.5–6.6) reported ever e-cigarette use, including 20.2% (95% CI = 18.7–21.8) among ever cigarette smokers and 0.9% (95% CI = 0.7–1.1) among never cigarette smokers. Current e-cigarette use was 6.9% (95% CI = 6.2–7.8) among ever cigarette smokers and 0.3% (95% CI = 0.2–0.4) among never cigarette smokers. From 2011 to 2013, weighted population estimates among students who were never cigarette smokers but had ever used an e-cigarette increased over 3-fold, from approximately 79,000 (95% CI = 44,000–114,000) to over 263,000 (95% CI = 176,000–351,000).

Intention to Smoke Cigarettes

Overall, 21.9% (95% CI = 21.2–22.6) of never cigarette smokers had smoking intentions. Smoking intention was 43.9% (95%

CI = 37.1–50.9) among ever e-cigarette users compared with 21.5% (95% CI = 20.9–22.2) among those who had never tried e-cigarettes ($p < .001$).

Prevalence of smoking intention varied by demographic and tobacco use characteristics among never cigarette smokers (Table 1). Intention to smoke was highest among Hispanic students (27.5%) compared with other race/ethnicity groups ($p < .001$). Intention to smoke was 26.7% (95% CI = 25.5–27.9) among those who lived with a tobacco-using household member compared with 19.4% (95% CI = 18.6–20.2) among those who did not (Table 1).

Among all never smokers, 7.7% (95% CI = 7.1–8.2) had ever used another combustible tobacco product and 3.0% (95% CI = 2.6–3.3) had ever used other noncombustible tobacco products. Current use was 2.6% for other combustible tobacco products and 1.0% (95%

CI = 0.9–1.2) for other noncombustible tobacco products. Intentions to smoke cigarettes were significantly higher among those who had ever used other combustible (38.3%; 95% CI = 36.2–40.5) or other noncombustible tobacco products (41.4%; 95% CI = 38.5–44.3) than among nonuser ($p < .001$) (Table 1). Current users also had similarly higher rates of smoking intention compared to noncurrent users (Table 1). In addition, intention to smoke in 2013 was significantly lower than in 2012 and 2011 ($p < .001$) (Table 1).

Pro-Tobacco Advertisement Exposure and Other Tobacco Use

Of all never cigarette smokers, 90% reported some level of exposure to pro-tobacco advertising. Youth who reported exposure

Table 1. Smoking Intention and Characteristics of Middle and High School Students Who Were Never Smokers: National Youth Tobacco Survey, 2011–2013

Characteristics and exposures		Never smoker (<i>n</i> = 43,873)	Never smoker, no smoking intention (<i>n</i> = 33,951)	Never smoker, smoking intention (<i>n</i> = 9,897)	Chi-squared test <i>p</i>
		% (95% CI)	% (95% CI)	% (95% CI)	
Smoking intention	Yes	21.9 (21.2–22.6)	—	—	—
	No	78.1 (77.4–78.8)	—	—	
Year	2011	32.4 (28.2–36.9)	77.2 (75.8–78.5)	22.8 (21.5–24.2)	<.001
	2012	33.7 (30.1–37.4)	75.0 (74.1–75.9)	25.0 (24.1–25.9)	
	2013	33.9 (30.1–37.9)	82.1 (81.1–83.2)	17.9 (16.8–18.9)	
Sex	Female	50.4 (49.6–51.1)	78.4 (77.5–79.4)	21.6 (20.6–22.5)	.255
	Male	49.6 (48.9–50.4)	77.8 (77.0–78.6)	22.2 (21.4–23.0)	
School	Middle	51.2 (48.2–54.2)	78.7 (77.8–79.6)	21.3 (20.4–22.2)	.054
	High	48.8 (45.8–51.8)	77.4 (76.3–78.5)	22.6 (21.5–23.7)	
Race/ethnicity	Non-Hispanic White	55.4 (52.4–58.3)	79.4 (78.5–80.3)	20.6 (19.7–21.5)	<.001
	Non-Hispanic Black	14.2 (12.4–16.3)	80.3 (78.5–81.9)	19.7 (18.1–21.5)	
	Hispanic	19.6 (17.8–21.5)	72.5 (71.1–73.9)	27.5 (26.1–28.9)	
	Non-Hispanic other	10.8 (9.8–11.9)	79.0 (77.1–80.7)	21.0 (19.3–22.9)	
Internet ads	Yes	40.5 (39.6–41.3)	73.7 (72.7–74.7)	26.3 (25.3–27.3)	<.001
	No	59.5 (58.7–60.4)	81.2 (80.4–81.9)	18.8 (18.1–19.6)	
Magazine/newspaper ads	Yes	37.0 (36.1–37.8)	74.6 (73.5–75.6)	25.4 (24.4–26.5)	<.001
	No	63.0 (62.2–63.9)	80.2 (79.4–81.0)	19.8 (19.0–20.6)	
Retail ads	Yes	76.9 (76.0–77.8)	76.7 (75.9–77.5)	23.3 (22.5–24.1)	<.001
	No	23.1 (22.2–24.0)	82.9 (81.9–84.0)	17.1 (16.0–18.1)	
Television program/movie ads	Yes	69.2 (68.3–70.0)	76.7 (75.9–77.4)	23.3 (22.6–24.1)	<.001
	No	30.8 (30.0–31.7)	81.5 (80.4–82.6)	18.5 (17.4–19.6)	
Total number of distinct sources of pro-tobacco advertisements exposed to	None	10.0 (9.5–10.5)	87.0 (85.5–88.3)	13.0 (11.7–14.5)	<.001
	1–2	47.8 (47.1–48.6)	79.6 (78.8–80.5)	20.4 (19.5–21.2)	
	3–4	42.2 (41.4–43.0)	74.4 (73.4–75.3)	25.6 (24.7–26.6)	
Household member uses tobacco	Yes	34.3 (33.0–35.7)	73.3 (72.1–74.5)	26.7 (25.5–27.9)	<.001
	No	65.7 (64.3–67.0)	80.6 (79.8–81.4)	19.4 (18.6–20.2)	
Ever use of e-cigarettes	Yes	0.9 (0.7–1.1)	56.1 (49.1–62.9)	43.9 (37.1–50.9)	<.001
	No	99.1 (98.9–99.3)	78.5 (77.8–79.4)	21.5 (20.9–22.2)	
Other combustible tobacco products	Yes	7.7 (7.1–8.2)	61.7 (59.5–63.8)	38.3 (36.2–40.5)	<.001
	No	92.3 (91.8–92.9)	79.5 (78.8–80.2)	20.5 (19.8–21.2)	
Other noncombustible tobacco products	Yes	3.0 (2.6–3.3)	58.6 (55.7–61.5)	41.4 (38.5–44.3)	<.001
	No	97.0 (96.7–97.4)	78.7 (78.0–79.4)	21.3 (20.6–22.0)	
Current (past 30 days) use: e-cigarettes	Yes	0.3 (0.2–0.4)	58.2 (47.5–68.1)	41.8 (31.9–52.5)	<.001
	No	99.7 (99.6–99.8)	78.3 (77.6–79.0)	21.7 (21.0–22.4)	
Other combustible tobacco products	Yes	2.6 (2.4–2.9)	60.4 (56.4–64.3)	39.6 (35.7–43.6)	<.001
	No	97.4 (97.1–97.6)	78.6 (77.9–79.3)	21.4 (20.7–22.1)	
Other noncombustible tobacco products	Yes	1.0 (0.9–1.2)	59.3 (54.1–64.3)	40.7 (35.7–45.9)	<.001
	No	99.0 (98.8–99.1)	78.3 (77.6–79.0)	21.7 (21.0–22.4)	

CI = confidence interval.

to pro-tobacco advertisements had higher rates of intention to smoke than those without exposures on the internet (26.3%, 95% CI = 25.3–27.3 vs. 18.8%, 95% CI = 18.1–19.6; $p < .001$), magazine and newspapers (25.4%, 95% CI = 24.4–26.5 vs. 19.8%, 95% CI = 19.0–20.6; $p < .001$), retail environments (23.3%, 95% CI = 22.5–24.1 vs. 17.1; 95% CI = 16.0–18.1; $p < .001$), and television programs and movie advertisements (23.3%; 95% CI = 22.6–24.1 vs. 18.5%; 95% CI = 17.4–19.6; $p < .001$) (Table 1). A significant dose response in intention to smoke was evident by exposure to increasing numbers of pro-tobacco advertisement sources. Intention to smoke was 13.0% (95% CI = 11.7–14.5) among those with no exposure, 20.4% (95% CI = 19.5–21.2) among those with 1–2 exposure sources and 25.6% (95% CI = 24.7–26.6) among those with 3–4 sources ($p < .001$) (Table 1).

Multivariate Analyses

Table 2 reports results from two multivariate models assessing independent predictors of intention to smoke. Model 1 included ever use variables for e-cigarettes, other combustible, and noncombustible tobacco use. In this model, among never-smoking students, those who had ever used e-cigarettes were more likely to have smoking intentions than never users of e-cigarettes (AOR = 1.70; 95%

CI = 1.24–2.32). Similarly, those who had ever used some other combustible product had increased odds of smoking intention (AOR = 2.08; 95% CI = 1.87–2.32) as did those who had ever used a non-combustible product (AOR = 1.92; 95% CI = 1.65–2.23).

A dose-response relationship between exposure to pro-tobacco advertisements and intention to smoke was also observed (Table 2). Students who reported exposure to 3–4 distinct sources of pro-tobacco advertisements had greater odds of smoking intention (AOR = 2.30; 95% CI = 1.97–2.68) than those with no exposure. Similarly, those who had 1–2 exposure sources had greater odds of smoking intention than those with no exposure (AOR = 1.68; 95% CI = 1.45–1.95; $p < .001$).

Hispanic students were more likely to have smoking intentions than non-Hispanic White students (AOR = 1.60; 95% CI = 1.46–1.75; $p < .001$) (Table 2). In addition, those who lived with a household member who uses tobacco were more likely to have intentions to smoke (AOR = 1.37; 95% CI = 1.28–1.46) compared with those who did not live with a tobacco user.

Model 2, which assessed the association of current use of e-cigarettes, other combustible, and noncombustible tobacco products with intention to smoke, produced similar results as Model 1 (Table 2). Current use of e-cigarettes was associated with intention to smoke (AOR = 1.87; 95% CI = 1.17–2.97), and all other factors

Table 2. Factors Associated With Smoking Intention Among Middle and High School Students Who Are Never Smokers, NYTS 2011–2013

		Never Smoker Models			
		Model 1: Ever use of tobacco products		Model 2: Current use of tobacco products	
		AOR (95% CI)	<i>p</i>	AOR (95% CI)	<i>p</i>
Year	2011	Referent	---	Referent	---
	2012	1.12 (1.02–1.23)	.014	1.13 (1.04–1.24)	.007
	2013	0.70 (0.63–0.78)	<.001	0.72 (0.65–0.81)	<.001
Sex	Female	Referent	---	Referent	---
	Male	1.03 (0.96–1.11)	.373	1.06 (0.99–1.14)	.103
School	Middle	Referent	---	Referent	---
	High	0.95 (0.88–1.11)	.204	1.01 (0.94–1.10)	.732
Race/ethnicity	Non-Hispanic White	Referent	---	Referent	---
	Non-Hispanic Black	0.97 (0.86–1.09)	.624	0.98 (0.88–1.10)	.755
	Hispanic	1.60 (1.46–1.75)	<.001	1.58 (1.44–1.73)	<.001
	Non-Hispanic Other	1.07 (0.95–1.20)	.262	1.06 (0.95–1.20)	.300
Total number of distinct sources of pro-tobacco ads exposed to	None	Referent	---	Referent	---
	1–2	1.68 (1.45–1.95)	<.001	1.67 (1.45–1.93)	<.001
	3–4	2.30 (1.97–2.68)	<.001	2.31 (2.00–2.67)	<.001
Household member uses tobacco	No	Referent	---	Referent	---
	Yes	1.37 (1.28–1.46)	<.001	1.41 (1.32–1.52)	<.001
Ever use of e-cigarettes	No	Referent	---	---	---
	Yes	1.70 (1.24–2.32)	<.001	---	---
Other combustible tobacco products	No	Referent	---	---	---
	Yes	2.08 (1.87–2.32)	<.001	---	---
Other noncombustible tobacco products	No	Referent	---	---	---
	Yes	1.92 (1.65–2.23)	<.001	---	---
Current (past 30 days) use of e-cigarettes	No	---	---	Referent	---
	Yes	---	---	1.87 (1.17–2.97)	.009
Other combustible tobacco products	No	---	---	Referent	---
	Yes	---	---	2.03 (1.69–2.45)	<.001
Other noncombustible tobacco products	No	---	---	Referent	---
	Yes	---	---	1.77 (1.40–2.24)	<.001

CI = confidence interval; AOR = adjusted odds ratio.

remained significant in the model. Additional models with categorical responses (ever, current, never) for combustible and noncombustible product use gave almost identical results.

To assess potential effect of our definition of intention to smoke, we also fit additional models using two alternative definitions. The first definition only classified respondents as having intentions if they responded “definitely yes” or “probably yes” to the two intentions questions and the second definition used a single question to classify intentions (i.e., smoking in the next year) instead of our two question definitions. Model results for these alternative definitions did not differ significantly for any factor except in the single question definition model where being in high school (compared with middle school) showed a statistically significant association with intention to smoke.

Discussion

In a nationally representative sample of middle and high school students who had never smoked cigarettes, we found that youth who had used e-cigarettes were nearly two times more likely to have intentions to smoke conventional cigarettes than youth who had never used e-cigarettes. Among youth who had ever used e-cigarettes, 43.9% had intention to smoke conventional cigarettes within the next year compared with 21.5% of never e-cigarette users. Although the number of e-cigarette users who had never used cigarettes was small, the number increased 3-fold between 2011 and 2013. By 2013, over a quarter million students who had never smoked cigarettes had used e-cigarettes. Our study also found elevated rates of smoking intention among youth who had used other combustible products such as cigars, cigarillos, pipes, or hookahs, as well as among those who used noncombustible tobacco products. These findings highlight the importance of enhanced efforts to prevent all forms of tobacco use among youth, including e-cigarettes.

Consistent with previous studies, exposure to pro-tobacco advertisements was also associated with smoking intentions in this study.^{24,27} We found a dose response in youth smoking intentions across increased levels of exposure to pro-tobacco advertisements. This finding is of particular concern at a time when ENDS advertising is increasing rapidly; e-cigarette advertising expenditures in magazines, television, newspapers, and the Internet grew nearly 3-fold during 2011–2012, from \$6.4 million to \$18.3 million, and totaled \$60 million in 2013.^{8,28} Of note, in the present study, 40% of never smokers reported exposure to pro-tobacco advertisements on the internet, which could place them at heightened risk of non-face-to-face e-cigarette sales. Internet sales are estimated to be a large portion of the e-cigarette market and are currently not part of existing regulation. Furthermore, e-cigarette advertising is currently permitted on television, which is exposing youth to smoking images for the first time in nearly four decades.²⁹

Independent of e-cigarette use, our multivariate analysis showed that youth who used noncombustible products had elevated intentions to smoke cigarettes, reinforcing prior research.²⁵ Although youth e-cigarette use is receiving considerable attention, youth noncombustible use is also a major public health concern. A growing number of noncombustible products are on the market, youth use is high,¹¹ and industry practices include features known to appeal to youth, such as flavorings and point-of-sale and print promotions.^{30,31} Similarly, use of other combustible products was associated with elevated odds of smoking intentions in the present study. Among never cigarette smokers, 7.7% had used other combustible products including cigars, cigarillos, pipes, or hookahs. Our findings also indicated higher prevalence of use and intentions among Hispanic youth and early interventions focusing on Hispanic youth could help avert

tobacco use disparities. This study reinforces the importance of surveillance and prevention of all tobacco products for youth.

Our study also highlights several methodological issues of potential relevance for youth tobacco use surveillance and for future investigations about ENDS and conventional smoking intentions. First, patterns of tobacco use among youth have grown in complexity, with many youth using multiple products³² and numerous new products emerging in the market.³³ Given the rapid proliferation of tobacco products, particularly of different types of ENDS,¹ close monitoring of market trends may be necessary to identify new product names and shifts in product popularity that could help inform surveillance questionnaire updates. Secondly, the present analysis identified three highly vulnerable sub-groups within never cigarette smokers, for example, e-cigarette users, other combustible users, and noncombustible users. The heightened risk of these groups may have been obscured within the broader never-smoker groups in previous susceptibility and intentions analyses that did not assess or control for product use other than conventional cigarettes.²⁴ Use of a broader definition of tobacco products in future research that incorporates not only cigarettes, but also other combustible, smokeless tobacco products and ENDS, will help capture the increasing number of youth who do not smoke cigarettes but use other products such as flavored little cigars and hookahs,³⁴ smokeless tobacco or ENDS.

We conducted our smoking intentions analyses among youth who had never smoked cigarettes. This approach aligns with the findings of previous studies that determined that intentions not to smoke had a protective effect for never smokers as well as for those with smoking experience.^{22,23} In the present study, the two questions used to define smoking intention were future intention (use one year from now) and peer influence (would you smoke if a best friend offered you a cigarette). Although this two question definition of intention to smoke varies from prior studies that validated a single question measure for intentions^{23,35} and a three question measure for susceptibility,²¹ we had only two questions consistently available across all three years of NYTS. While it is possible that we under or overestimated smoking intention due to these definitional constraints, we fit additional logistical regression models using a more conservative intentions definition as well as a single question for intentions and found similar results.

In addition, our results showed that the overall percentage of youth who reported smoking intentions decreased significantly in 2013. To control for this in our models, we included survey year in all analyses, but on-going monitoring of smoking intentions is needed to assess whether this decline continues.

This study is subject to at least four limitations. First, the data were self-reported and subject to potential misreporting. Secondly, while our definitions of combustible, smokeless tobacco product and ENDS use included a comprehensive list of tobacco products, we were restricted to products included in all three survey years. Third, we may have underestimated ENDS use, as NYTS asked only about e-cigarette use, giving only two brands as examples, and did not capture electronic hookah, e-pens, or a host of other new and emerging products that may be referred to by a variety of names among youth.¹ Likewise, we may not have captured all exposure to e-cigarette marketing since the advertisement exposure questions asked about “tobacco products.” Finally, this study analyzed data from never smokers and did not account for youth who may have previously experimented with conventional cigarettes. E-cigarette use could also be associated with increased intentions to smoke cigarettes among experimenters. Additionally, NYTS was conducted

among in-school youth, which may have led to biases³⁶ because youth who have dropped out of school have higher smoking prevalence than in-school youth.³⁷

Since NYTS is a cross-sectional survey, we cannot determine the causal or temporal direction of the association between e-cigarettes and intention to smoke among youth, but either scenario raises public health concerns. If youth with intentions to smoke initiate ENDS, they are being exposed to nicotine, which can be harmful to adolescent brain development regardless of whether they progress to cigarette smoking.¹⁵ Overcoming the barriers to obtaining and using e-cigarettes could also make youth more likely to use conventional cigarettes. In addition, e-cigarette use can lead to nicotine addiction, which increases risk of combustible product use.¹⁵ On the other hand, if the temporal direction is reversed and ENDS use leads youth to develop intentions to smoke conventional cigarettes, then ENDS use could result in higher smoking prevalence among youth and ultimately in higher smoking-related morbidity and mortality. Although longitudinal studies could empirically validate the predictive value of a smoking intention measure in the context of ENDS, a controlled trial assessing ENDS use among youth would not be ethical given the known harms of nicotine. Irrespective of causality, nonsmoking youth who use e-cigarettes have nearly double the rate of smoking intention, a finding which, from a public health perspective, merits prevention efforts to protect youth.

Our nationally representative findings that youth e-cigarette use is associated with intentions to smoke conventional cigarettes have important public health implications. Interventions to prevent youth access and exposure to ENDS marketing on the internet, television, and elsewhere could help reduce product appeal and use. For example, some state and local authorities have already established a minimum legal age of purchase and have prohibited use of e-cigarettes in smoke-free establishments³⁸ and efforts to protect youth are expanding. Furthermore, when FDA's proposed rule released in April 2014 to extend its jurisdictional authorities to other tobacco products is finalized, FDA will have authority to regulate the manufacture, marketing, and distribution of ENDS, which includes, in the proposed rule, establishing federal regulations concerning minimum age of purchase, and requiring health warnings on products. There is also the potential to establish product standards in the future focused on diminishing the product's appeal, addictiveness, and/or harm.¹⁸ For youth, further research on the impact of e-cigarette marketing, perceptions about the health risks of e-cigarettes, and the impact of youth e-cigarette use on the transition to conventional cigarette or cigar use could help inform public health efforts, including regulation. However, while further research may be needed to clarify the net population impact of ENDS for adults, youth are particularly susceptible to the effects of nicotine and timely prevention efforts are needed to protect this vulnerable population. Enhancement of tobacco prevention efforts at the local, state and federal levels could help avert premature death and disease for 5.6 million of today's children.

Declaration of Interests

None declared.

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