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Original investigation

Trends in Awareness and Use of Electronic Cigarettes Among US Adults, 2010–2013

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Abstract

Introduction: Electronic cigarette (e-cigarette) marketing has increased considerably since the product entered the US market in 2007, thereby warranting additional surveillance to monitor recent trends in population-level awareness and utilization. We assessed the prevalence, characteristics, and trends in e-cigarette awareness and use among nationally representative samples of US adults during 2010–2013.

Methods: Data came from the 2010–2013 HealthStyles survey, an annual consumer-based web survey of US adults aged ≥ 18 years. Sample sizes ranged from 2,505 (2010) to 4,170 (2012). Descriptive statistics were used to assess e-cigarette awareness, ever use, and current use (use within the past 30 days) overall and by sex, age, race/ethnicity, education, income, US region, and cigarette smoking status. Trends were assessed using logistic regression.

Results: During 2010–2013, increases ($p < .05$) were observed for e-cigarette awareness (40.9%–79.7%), ever use (3.3%–8.5%), and current use (1.0%–2.6%). Awareness increased among all socio-demographic subpopulations during 2010–2013 ($p < .05$); an increase in ever use of e-cigarettes occurred among all sociodemographic groups except those aged 18–24 years, Hispanics, and those living in the Midwest ($p < .05$). During 2010–2013, ever use increased among current (9.8%–36.5%) and former (2.5%–9.6%) cigarette smokers ($p < .05$), but it remained unchanged among never smokers (1.3%–1.2%).

Conclusions: Awareness and use of e-cigarettes increased considerably among US adults during 2010–2013. In 2013, more than one-third of current cigarette smokers reported having ever used e-cigarettes. Given the uncertain public health impact of e-cigarettes, continued surveillance of emerging use patterns is critical for public health planning.

Introduction

Electronic nicotine delivery systems (ENDS) are battery powered devices that provide doses of nicotine and other additives to the user in an aerosol. There are currently multiple types of ENDS available

in the US marketplace, including electronic cigarettes, or e-cigarettes, as well as e-hookahs, e-cigars, and e-pipes. Some of these products are disposable varieties, while others can be refilled or recharged for repeated use.¹ Depending on the brand, ENDS typically contain nicotine, a component to produce the aerosol (e.g., propylene glycol

or glycerol), and flavorings (e.g., fruit, mint chocolate).² Harmful or potentially harmful constituents have also been documented in some ENDS, including tobacco-specific nitrosamines, aldehydes, metals, volatile organic compounds, phenolic compounds, polycyclic aromatic hydrocarbons, and tobacco alkaloids, but at lower levels than in conventional cigarettes.³

The regulatory status of ENDS is currently pending in many countries. In the United States, the 2009 Family Smoking Prevention and Tobacco Control Act gave the Food and Drug Administration (FDA) the authority to regulate tobacco products, including the ability to propose certain requirements and restrictions on manufacturing, marketing, sale, and distribution.⁴ Only ENDS that are marketed for therapeutic purposes are currently regulated by the FDA. In April 2014, the FDA proposed to extend the agency's authority to cover additional tobacco products, including ENDS; however, the proposal must still undergo public comment and implementation could take several years.⁵ In other countries, ENDS have been classified and regulated as medical products, while some have banned the sale, importation, and advertising of the products entirely.⁶ Absent any regulation in most countries, the ENDS landscape—including product design, availability, sales, marketing, and use—is one of rapid change and high variability with little oversight. Additionally, significant questions remain regarding ENDS' impact on individual and population health.⁷ Proponents contend that ENDS are less harmful to health than conventional cigarettes and may help some smokers quit⁸; however, there is currently no conclusive scientific evidence that ENDS promote long-term cessation,⁹⁻¹⁵ and the products are not FDA-approved cessation aids.¹⁶ Additional public health concerns related to ENDS include initiation of nicotine addiction in adolescents and the potential for progression to combusted tobacco use among non-tobacco users, long-term dual use among current smokers, and relapse of smoking among former smokers.¹⁷

Despite uncertainty over the public health impact of ENDS, rapid increases in awareness, experimentation, and recent use have occurred among US adults and youth.^{18,19} During 2010–2011, awareness of e-cigarettes among US adults increased from 40.9% to 57.9%; additionally, ever use of e-cigarettes among US adults increased from 3.3% to 6.2%, with 21.2% of current cigarette smokers reporting that they had ever used e-cigarettes in 2011.¹⁹ Among US middle and high school students, ever use of e-cigarettes increased from 4.7% to 10.0% during 2011–2012, representing an estimated 1.8 million students in grade 6–12 who had ever used the products in 2012; over 500,000 students reported using e-cigarettes in the past 30 days, three-quarters of whom reported that they had also used conventional cigarettes during the same period.¹⁸ This increase in e-cigarette use was mirrored by considerable increases in calls to poison centers regarding an exposure to the product itself or to the nicotine liquid; monthly calls increased from one in September 2010 to 215 in February 2014.²⁰ Consumer awareness, experimentation, and current use of ENDS are likely influenced by increased advertising for these products; e-cigarette advertising expenditures across multiple media channels—including magazines, television, newspapers, and the Internet—has increased nearly three-fold, from \$6.4 million in 2011 to \$18.3 million in 2012.²¹

To date, national data on awareness and use of ENDS among US adults is limited, and the research that has been conducted has primarily focused on measures assessed during a single year.²²⁻²⁴ King and colleagues¹⁹ assessed changes in e-cigarette awareness and ever use during 2010–2011; however, no study has assessed

recent estimates or long-term trends in these indicators over time. The literature has also largely focused on ever use due to limited sample size and instability of estimates of more recent use of these products.¹⁹ To address this need and to help inform public health and regulatory decisions, we analyzed data from a national cross-sectional web-based survey to determine the prevalence, trends, and sociodemographic correlates of awareness, ever use, and current use of e-cigarettes among US adults during 2010–2013.

Methods

Data Source

Data were obtained from *Styles*, a series of national consumer panel surveys administered in seasonal waves. The *HealthStyles* survey assesses exposure to health-related information and self-reported symptoms, risk factors, and diseases among US adults aged ≥ 18 years old. In preparation for transitioning to online-only methodology, both mail (August–September) and web (July–August) versions of *HealthStyles* were fielded in 2010. Only a web version was fielded in 2011 (July–August), 2012 (June–July), and 2013 (June–July). To ensure comparability across survey waves, the 2010 mail-based data were excluded from this analysis.

Sample

For the 2010–2013 web-based *Styles*, sampling and data collection were conducted by Knowledge Networks, which recruited a nationally representative online panel. Panel members are randomly recruited by probability-based sampling (random-digit dial and address-based) to reach respondents regardless of whether they have a landline phone or Internet access. Households are provided with a computer and Internet access as needed. The panel is continuously replenished and maintains approximately 50,000 panelists. A random sample of panelists was asked to participate in the web-based *HealthStyles* as follows: 2010 ($n = 3,922$), 2011 ($n = 5,865$), 2012 ($n = 6,402$), and 2013 ($n = 6,105$). Respondents who did not answer at least half the questions were removed from the datasets (2010, $n = 15$; 2011, $n = 13$; 2012, $n = 42$; 2013, $n = 79$). Final sample sizes were 2,505 in 2010, 4,050 in 2011, 4,170 in 2012, and 4,033 in 2013. Response rates were 63.9% in 2010, 69.1% in 2011, 65.1% in 2012, and 66.1% in 2013.

Measures

Awareness

Awareness of e-cigarettes was assessed using the question, “Which, if any, of the following products have you heard of”? Respondents who selected “electronic cigarettes or e-cigarettes” were considered to be aware of e-cigarettes.

Ever Use

Ever use of e-cigarettes was assessed using the question, “Have you ever tried any of the following products, even just one time”? Respondents who selected “electronic cigarettes or e-cigarettes” were considered to be ever e-cigarette users.

Current Use

Current use of e-cigarettes was assessed by the question, “In the past 30 days, which of the following products have you used at least once”? Respondents who selected “electronic cigarettes or e-cigarettes” were considered to be current e-cigarette users.

Respondent Characteristics

Respondent characteristics included: sex (male or female); age group (18–24, 25–44, 45–64, or ≥65 years); race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic “other,” or Hispanic); educational attainment (less than high school, high school graduate, some college, or college graduate); annual household income (<\$15,000, \$15,000–\$24,999, \$25,000–\$39,999, \$40,000–\$59,999, or ≥\$60,000); US Census region (Northeast, Midwest, South, or West); and cigarette smoking status (current, former, or never). Current smokers were defined as respondents who smoked ≥100 cigarettes in their lifetime and reported smoking “everyday” or “some days” at the time of survey. Former smokers were respondents who smoked ≥100 cigarettes in their lifetime and reported smoking “not at all” at the time of survey. Never smokers were respondents who reported that they had not smoked ≥100 cigarettes in their lifetime.

Analysis

Data were analyzed using SAS v9.2 and weighted according to 2010–2013 Current Population Survey population proportions for nine factors: sex, age, household income, race/ethnicity, household size, education, census region, metro status, and prior Internet access. Point estimates and 95% confidence intervals (CI) were calculated overall and by each respondent characteristic; estimates with a relative standard error of ≥40% were not reported. Additionally, logistic regression models were fitted to determine adjusted odds ratios (OR) and 95% CI's for the following dependent variables: e-cigarette awareness, ever use, and current use; independent variables included sex, age group, race/ethnicity, educational attainment, US Census region, and cigarette smoking status. Logistic regression was also used to assess trends in awareness and ever use of e-cigarettes during 2010–2013. Due to limited sample size, data on current use were aggregated for 2010/2011 and 2012/2013; chi-squared tests were used to assess significance between these groups ($p < .05$). Respondents with missing data were excluded from the analysis; the extent of missing data was ≤4% for the awareness, ever use, and current use variables in each survey year.

Results

Awareness

During 2010–2013, awareness of e-cigarettes among US adults increased from 40.9% (95% CI = 38.6–43.2) to 79.7% (95% CI = 77.7–81.6) ($p < .05$) (Table 1). Increases in awareness were observed across all subpopulations during 2010–2013, irrespective of sex, age, race/ethnicity, education, income, region, or current cigarette smoking status ($p < .05$).

Following multivariate adjustment, females had lower odds of awareness than males in 2010 (OR = 0.8; 95% CI = 0.6–0.9) and 2012 (OR = 0.7; 95% CI = 0.6–0.9). By age group, adults aged ≥65 had lower odds than those aged 18–24 in 2010 (OR = 0.3; 95% CI = 0.2–0.4), 2011 (OR = 0.4; 95% CI = 0.3–0.6), and 2012 (OR = 0.7; 95% CI = 0.4–0.9). By race/ethnicity, non-Hispanic Blacks had lower odds than non-Hispanic Whites in 2010 (OR = 0.5; 95% CI = 0.3–0.7), 2011 (OR = 0.7; 95% CI = 0.5–0.9), 2012 (OR = 0.6; 95% CI = 0.4–0.8), and 2013 (OR = 0.6; 95% CI = 0.4–0.9); Hispanics had lower odds than non-Hispanic Whites in 2011 (OR = 0.5; 95% CI = 0.4–0.7) and 2012 (OR = 0.4; 95% CI = 0.3–0.5); and those of non-Hispanic other races had lower odds than non-Hispanic Whites in 2011 (OR = 0.6; 95% CI = 0.4–0.9)

and 2012 (OR = 0.6; 95% CI = 0.4–0.9). By education, adults with a high school diploma (OR = 1.7; 95% CI = 1.1–2.5), some college (OR = 2.1; 95% CI = 1.4–3.1), or a college degree (OR = 2.4; 95% CI = 1.6–3.5) had greater odds than those with less than a high school diploma in 2011. Those with annual household income of \$40,000–\$59,999 (OR = 1.6; 95% CI = 1.1–2.4) or ≥\$60,000 (OR = 1.7; 95% CI = 1.2–2.4) had greater odds than those with annual household income of <\$15,000 in 2012. No significant variations in awareness were observed by region in any year. By cigarette smoking status, former smokers had greater odds compared to never smokers in 2010 (OR = 1.7; 95% CI = 1.3–2.2), 2011 (OR = 2.2; 95% CI = 1.8–2.8), 2012 (OR = 1.9; 95% CI = 1.5–2.4), and 2013 (OR = 2.1; 95% CI = 1.5–2.9). Similarly, current cigarette smokers had greater odds than never smokers in 2010 (OR = 3.0; 95% CI = 2.3–4.0), 2011 (OR = 4.3; 95% CI = 3.2–5.8), 2012 (OR = 4.4; 95% CI = 3.2–6.3), and 2013 (OR = 3.7; 95% CI = 2.1–6.4).

Ever Use

During 2010–2013, ever use of e-cigarettes among US adults increased from 3.3% (95% CI = 2.5–4.2) to 8.5% (95% CI = 7.3–9.8) ($p < .05$) (Table 2). Increases in ever use were observed across all population subgroups during 2010–2013 ($p < .05$), with the exception of adults aged 18–24 years, those of Hispanic race/ethnicity, those living in the Midwest, and never cigarette smokers.

By smoking status, ever use of e-cigarettes was higher among current cigarette smokers than former and never smokers in every survey year (Table 2). Among ever e-cigarette smokers, the proportion of current cigarette smokers was 62.6% in 2010, 57.3% in 2011, 66.1% in 2012, and 63.4% in 2013; the proportion of never cigarette smokers was 18.6% in 2010, 11.2% in 2011, 16.5% in 2012, and 8.7% in 2013 (data not shown).

Following multivariate adjustment, females had greater odds of ever use than males in 2013 (OR = 1.5; 95% CI = 1.1–2.2). By age group, adults aged 25–44 had lower odds than those aged 18–24 in 2010 (OR = 0.4; 95% CI = 0.2–0.9) and 2013 (OR = 0.4; 95% CI = 0.2–0.9); adults aged 45–64 had lower odds than those aged 18–24 in 2010 (OR = 0.4; 95% CI = 0.2–0.8), 2011 (OR = 0.5; 95% CI = 0.2–0.9), and 2013 (OR = 0.3; 95% CI = 0.1–0.7); and adults aged ≥65 had lower odds than those aged 18–24 in 2010 (OR = 0.2; 95% CI = 0.1–0.6), 2011 (OR = 0.3; 95% CI = 0.1–0.7), and 2013 (OR = 0.2; 95% CI = 0.1–0.4). By education, adults with some college had greater odds than those with a high school diploma in 2012 (OR = 2.0; 95% CI = 1.1–3.8). No significant variations in ever use were observed by race/ethnicity, income, or region in any year. By cigarette smoking status, former smokers had greater odds than never smokers in 2010 (OR = 2.8; 95% CI = 1.1–7.3), 2011 (OR = 8.0; 95% CI = 4.2–15.4), 2012 (OR = 3.2; 95% CI = 1.9–5.4), and 2013 (OR = 13.4; 95% CI = 7.6–24.0). Current cigarette smokers had greater odds than never smokers in 2010 (OR = 10.5; 95% CI = 4.9–22.5), 2011 (OR = 26.5; 95% CI = 14.9–46.9), 2012 (OR = 21.3; 95% CI = 13.0–35.0), and 2013 (OR = 73.1; 95% CI = 42.7–124.9).

Current Use

Current use of e-cigarettes among US adults was higher during 2012/2013 (1.9%, 95% CI = 1.5–2.3) than 2010/2011 (1.3%; 95% CI = 1.0–1.7) ($p < .05$) (Table 3). By population subgroup, current use was higher during 2012/2013 than 2010/2011 among non-Hispanic Whites (2.2% vs. 1.5%), those with a college degree

Table 1. Awareness of E-Cigarettes Among US Adults: HealthStyles, 2010–2013

Characteristic	% (95% CI)				AOR (95% CI) ^a			
	2010	2011	2012	2013	2010	2011	2012	2013
Overall	<i>n</i> = 2,505	<i>n</i> = 4,050	<i>n</i> = 4,170	<i>n</i> = 4,033		<i>n</i> = 2,427	<i>n</i> = 3,969	<i>n</i> = 3,697
	40.9 (38.6–43.2)	57.9 (55.8–60.0)	67.2 (65.2–69.2)	79.7 (77.7–81.6) ^b	NA	NA	NA	NA
Sex								
Male	44.1 (40.7–47.5)	60.9 (57.9–63.8)	71.7 (68.9–74.4)	80.0 (78.0–83.7) ^b	1.00	1.00	1.00	1.00
Female	37.9 (34.7–41.1)	55.1 (52.2–58.0)	63.0 (60.2–65.8)	78.6 (75.9–81.3) ^b	0.8 (0.6–0.9)	0.9 (0.7–1.0)	0.7 (0.6–0.9)	0.8 (0.7–1.1)
Age (years)								
18–24	45.0 (37.4–52.6)	56.7 (49.5–63.8)	67.3 (61.1–73.4)	75.3 (68.6–82.1) ^b	1.00	1.00	1.00	1.00
25–44	46.0 (42.0–50.0)	58.9 (55.3–62.6)	66.2 (62.6–69.9)	75.8 (71.9–79.6) ^b	0.9 (0.6–1.4)	0.8 (0.6–1.2)	0.9 (0.6–1.3)	0.8 (0.5–1.3)
45–64	43.4 (39.7–47.2)	63.5 (60.4–66.6)	69.5 (66.5–72.5)	83.7 (81.0–86.5) ^b	0.8 (0.5–1.1)	0.9 (0.6–1.2)	0.9 (0.6–1.2)	1.3 (0.8–2.0)
≥65	21.4 (16.9–25.9)	45.2 (40.6–49.8)	64.4 (60.1–68.7)	82.0 (78.2–85.8) ^b	0.3 (0.2–0.4)	0.4 (0.3–0.6)	0.7 (0.4–0.9)	1.1 (0.7–1.8)
Race/ethnicity								
White, NH	44.3 (41.5–47.2)	62.6 (60.3–64.9)	72.7 (70.7–74.8)	82.8 (80.8–84.8) ^b	1.00	1.00	1.00	1.00
Black, NH	25.6 (19.7–31.4)	50.0 (43.0–57.0)	59.0 (52.4–65.6)	73.4 (66.5–80.4) ^b	0.5 (0.3–0.7)	0.7 (0.5–0.9)	0.6 (0.4–0.8)	0.6 (0.4–0.9)
Other, NH	41.8 (32.6–51.1)	50.9 (43.0–58.8)	60.7 (51.8–69.7)	73.1 (63.4–82.8) ^b	0.9 (0.6–1.5)	0.6 (0.4–0.9)	0.6 (0.4–0.9)	0.7 (0.4–1.1)
Hispanic	36.2 (30.1–42.3)	44.4 (37.8–51.1)	50.7 (44.4–57.1)	72.7 (66.1–79.2) ^b	0.7 (0.5–1.0)	0.5 (0.4–0.7)	0.4 (0.3–0.5)	0.7 (0.5–1.0)
Education								
<High school	40.3 (33.9–46.7)	42.6 (35.0–50.2)	65.6 (58.8–72.5)	76.4 (69.5–83.4) ^b	1.00	1.00	1.00	1.00
High school	41.0 (36.8–45.2)	56.4 (52.6–60.3)	66.2 (62.5–70.0)	80.3 (77.0–83.7) ^b	1.2 (0.9–1.7)	1.7 (1.1–2.5)	1.0 (0.7–1.5)	1.3 (0.8–2.1)
Some college	40.6 (36.3–44.9)	62.5 (59.0–66.0)	69.6 (66.3–72.9)	80.7 (77.2–84.2) ^b	1.2 (0.9–1.7)	2.1 (1.4–3.1)	1.2 (0.8–1.7)	1.5 (0.9–2.4)
College degree	41.4 (36.8–45.9)	61.7 (58.4–64.9)	66.5 (63.1–69.9)	79.5 (75.9–83.1) ^b	1.4 (1.0–2.0)	2.4 (1.6–3.5)	1.1 (0.7–1.6)	1.5 (0.9–2.5)
Household income								
<\$15,000	42.6 (36.2–49.0)	51.2 (44.3–58.1)	62.4 (55.0–69.8)	81.8 (75.3–88.2) ^b	1.00	1.00	1.00	1.00
\$15,000–\$24,999	43.5 (36.0–50.9)	54.6 (47.2–62.0)	61.8 (54.8–68.8)	82.1 (75.5–88.7) ^b	1.0 (0.7–1.6)	1.1 (0.7–1.7)	1.1 (0.7–1.8)	0.9 (0.5–1.8)
\$25,000–\$39,999	36.4 (31.1–41.6)	55.9 (50.4–61.3)	65.8 (60.5–71.0)	77.9 (72.7–83.0) ^b	0.8 (0.5–1.2)	1.4 (1.0–2.1)	1.4 (0.9–2.1)	0.9 (0.5–1.6)
\$40,000–\$59,999	41.7 (36.5–46.8)	53.9 (48.8–58.9)	67.7 (63.0–72.3)	74.7 (69.7–79.6) ^b	1.0 (0.7–1.4)	1.1 (0.7–1.6)	1.6 (1.1–2.4)	0.7 (0.4–1.2)
≥\$60,000	41.1 (37.3–44.8)	61.8 (59.0–64.6)	69.4 (66.7–72.1)	81.2 (78.5–83.9) ^b	1.0 (0.7–1.5)	1.4 (1.0–2.0)	1.7 (1.2–2.4)	1.1 (0.6–1.8)
US region								
Northeast	38.5 (32.7–44.3)	57.3 (52.6–62.0)	66.2 (61.7–70.7)	83.9 (80.0–87.9) ^b	1.00	1.00	1.00	1.00
Midwest	46.6 (42.0–51.2)	61.1 (57.0–65.1)	71.7 (67.9–75.4)	79.9 (75.9–83.8) ^b	1.4 (1.0–1.9)	1.1 (0.9–1.5)	1.2 (0.9–1.6)	0.8 (0.5–1.1)
South	38.4 (34.4–42.4)	57.9 (54.3–61.5)	65.7 (62.4–69.0)	79.5 (76.2–82.9) ^b	1.0 (0.7–1.4)	1.2 (0.9–1.5)	1.1 (0.8–1.4)	0.8 (0.6–1.2)
West	41.3 (36.7–46.0)	55.4 (51.0–59.7)	66.2 (61.8–70.5)	76.3 (71.8–80.8) ^b	1.1 (0.8–1.5)	1.0 (0.8–1.4)	1.2 (0.9–1.7)	0.8 (0.5–1.2)
Cigarette smoking								
Never smoker	34.6 (31.3–37.8)	50.1 (47.3–52.9)	60.5 (57.8–63.2)	74.5 (71.7–77.4) ^b	1.00	1.00	1.00	1.00
Former smoker	41.5 (37.0–46.0)	65.4 (61.7–69.1)	73.0 (69.4–76.6)	87.0 (84.0–90.1) ^b	1.7 (1.3–2.2)	2.2 (1.8–2.8)	1.9 (1.5–2.4)	2.1 (1.5–2.9)
Current smoker	59.3 (54.2–64.3)	76.9 (72.2–81.5)	84.7 (80.8–88.7)	91.3 (87.4–95.2) ^b	3.0 (2.3–4.0)	4.3 (3.2–5.8)	4.4 (3.2–6.3)	3.7 (2.1–6.4)

Statistically significant odds ratios are noted in bold. CI = confidence interval; AOR = adjusted odds ratio; NA = not applicable; NH = non-Hispanic

^aOdds ratios obtained using binary logistic regression model adjusted for all covariates listed in the table

^b*p*-trend < .05 during 2010–2013

Table 2. Ever Use of E-Cigarettes Among US Adults: HealthStyles, 2010–2013

Characteristic	% (95% CI)					AOR (95% CI) ^a						
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
Overall	<i>n</i> = 2,505	<i>n</i> = 4,050	<i>n</i> = 4,170	<i>n</i> = 4,033	<i>n</i> = 2,427	<i>n</i> = 3,969	<i>n</i> = 4,075	<i>n</i> = 3,793				
3.3 (2.5–4.2)	6.2 (5.2–7.3)	8.1 (7.0–9.3)	8.5 (7.3–9.8) ^b		1.00	NA	NA	NA	1.00	NA	NA	NA
Sex												
Male	3.0 (1.9–4.2)	5.8 (4.4–7.2)	7.6 (6.0–9.2)	8.7 (6.9–10.6) ^b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Female	3.7 (2.4–4.9)	6.6 (5.1–8.2)	8.6 (7.0–10.2)	8.3 (6.6–10.0) ^b	1.1 (0.6–2.0)	1.3 (0.9–1.9)	1.4 (1.0–1.9)	1.5 (1.1–2.2)				
Age (years)												
18–24	7.0 (3.0–10.9)	6.9 (3.2–10.6)	4.1 (1.8–6.3)	7.8 (4.2–11.4)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25–44	3.2 (1.9–4.4)	6.5 (4.7–8.4)	9.7 (7.5–12.0)	9.3 (7.0–11.6) ^b	0.4 (0.2–0.9)	0.6 (0.3–1.3)	1.8 (0.9–3.8)	0.4 (0.2–0.9)	1.8 (0.9–3.8)	1.8 (0.9–3.8)	0.4 (0.2–0.9)	0.4 (0.2–0.9)
45–64	3.1 (1.7–4.4)	6.8 (5.2–8.5)	9.7 (7.8–11.6)	9.8 (7.6–11.9) ^b	0.4 (0.2–0.8)	0.5 (0.2–0.9)	1.4 (0.7–3.0)	0.3 (0.1–0.7)	1.4 (0.7–3.0)	1.4 (0.7–3.0)	0.3 (0.1–0.7)	0.3 (0.1–0.7)
≥65	^c	3.8 (2.1–5.6)	4.9 (2.9–7.0)	5.2 (3.0–7.5)	0.2 (0.1–0.6)	0.3 (0.1–0.7)	0.9 (0.4–2.1)	0.2 (0.1–0.4)	0.9 (0.4–2.1)	0.9 (0.4–2.1)	0.2 (0.1–0.4)	0.2 (0.1–0.4)
Race/ethnicity												
White, NH	3.8 (2.7–4.9)	6.8 (5.6–8.1)	7.8 (6.6–9.1)	9.3 (7.8–10.8) ^b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black, NH	^c	4.5 (1.6–7.3)	13.3 (8.3–18.3)	8.6 (4.5–12.8)	0.7 (0.2–2.3)	0.6 (0.3–1.2)	1.5 (0.9–2.8)	0.9 (0.5–1.8)	0.7 (0.2–2.3)	0.6 (0.3–1.2)	1.5 (0.9–2.8)	0.9 (0.5–1.8)
Other, NH	^c	6.1 (1.8–10.4)	8.4 (3.6–13.3)	6.7 (2.1–11.4)	0.4 (0.1–1.3)	1.5 (0.8–2.8)	1.4 (0.7–2.9)	1.0 (0.4–2.7)	0.4 (0.1–1.3)	1.5 (0.8–2.8)	1.4 (0.7–2.9)	1.0 (0.4–2.7)
Hispanic	3.0 (1.0–5.1)	3.9 (1.1–6.7)	5.4 (3.0–7.8)	5.7 (2.4–8.9)	1.0 (0.4–2.2)	0.5 (0.3–1.2)	0.6 (0.3–1.1)	0.5 (0.2–1.1)	1.0 (0.4–2.2)	0.5 (0.3–1.2)	0.6 (0.3–1.1)	0.5 (0.2–1.1)
Education												
<High school	4.3 (1.7–6.9)	7.4 (3.4–11.4)	9.7 (5.7–13.8)	13.2 (8.1–18.4) ^b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
High school	4.0 (2.2–5.7)	7.5 (5.4–9.7)	8.2 (6.1–10.4)	8.5 (6.3–10.6) ^b	1.1 (0.5–2.5)	1.1 (0.5–2.1)	1.3 (0.7–2.4)	0.8 (0.5–1.4)	1.1 (0.5–2.5)	1.1 (0.5–2.1)	1.3 (0.7–2.4)	0.8 (0.5–1.4)
Some college	3.6 (2.0–5.1)	6.1 (4.6–7.7)	10.4 (8.2–12.6)	10.2 (7.8–12.6) ^b	1.1 (0.5–2.4)	0.9 (0.5–1.8)	2.0 (1.1–3.8)	1.2 (0.7–2.2)	1.1 (0.5–2.4)	0.9 (0.5–1.8)	2.0 (1.1–3.8)	1.2 (0.7–2.2)
College degree	2.0 (0.8–3.2)	4.4 (2.9–5.9)	5.0 (3.4–6.6)	4.8 (3.2–6.4) ^b	0.9 (0.4–2.1)	1.1 (0.5–2.2)	1.4 (0.7–2.9)	0.9 (0.5–1.8)	0.9 (0.4–2.1)	1.1 (0.5–2.2)	1.4 (0.7–2.9)	0.9 (0.5–1.8)
Household income												
<\$15,000	3.5 (1.5–5.6)	7.4 (4.2,10.5)	11.0 (6.8–15.2)	15.8 (9.4–22.2) ^b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
\$15,000–\$24,999	^c	5.7 (1.9–9.4)	12.5 (7.1–17.9)	8.0 (3.5–12.4)	1.0 (0.4–2.9)	0.7 (0.3–1.6)	1.5 (0.7–3.2)	0.6 (0.2–1.4)	1.0 (0.4–2.9)	0.7 (0.3–1.6)	1.5 (0.7–3.2)	0.6 (0.2–1.4)
\$25,000–\$39,999	3.5 (1.3–5.8)	9.4 (5.7–13.0)	9.8 (6.6–13.0) ^b	9.8 (6.6–13.0) ^b	1.2 (0.5–2.7)	1.9 (0.9–3.9)	1.3 (0.7–2.6)	1.1 (0.6–2.2)	1.2 (0.5–2.7)	1.9 (0.9–3.9)	1.3 (0.7–2.6)	1.1 (0.6–2.2)
\$40,000–\$59,999	2.5 (1.1–3.8)	4.7 (2.8–6.7)	8.7 (5.9–11.6)	8.4 (5.7–11.0) ^b	0.9 (0.4–2.2)	0.9 (0.5–1.9)	1.3 (0.7–2.5)	1.0 (0.5–2.0)	0.9 (0.4–2.2)	0.9 (0.5–1.9)	1.3 (0.7–2.5)	1.0 (0.5–2.0)
≥\$60,000	3.5 (2.1–4.9)	5.6 (4.3–7.0)	6.1 (4.8–7.4)	7.1 (5.5–8.7) ^b	1.5 (0.7–3.4)	1.4 (0.8–2.6)	1.1 (0.6–2.0)	1.1 (0.6–2.1)	1.5 (0.7–3.4)	1.4 (0.8–2.6)	1.1 (0.6–2.0)	1.1 (0.6–2.1)
US region												
Northeast	^c	5.6 (3.5–7.7)	6.6 (4.4–8.8)	7.1 (4.7–9.5)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Midwest	5.4 (3.1–7.6)	7.5 (5.1–9.9)	8.6 (6.2–11.0)	8.4 (5.7–11.1)	2.5 (0.8–7.4)	1.3 (0.7–2.2)	1.1 (0.6–1.9)	0.9 (0.5–1.7)	2.5 (0.8–7.4)	1.3 (0.7–2.2)	1.1 (0.6–1.9)	0.9 (0.5–1.7)
South	2.5 (1.4–3.6)	6.2 (4.4–8.0)	8.6 (6.6–10.6)	9.0 (6.8–11.1) ^b	1.0 (0.3–2.9)	1.1 (0.7–1.9)	1.0 (0.6–1.7)	1.2 (0.7–2.1)	1.0 (0.3–2.9)	1.1 (0.7–1.9)	1.0 (0.6–1.7)	1.2 (0.7–2.1)
West	3.7 (2.0–5.5)	5.5 (3.5–7.6)	8.2 (5.7–10.6)	9.0 (6.3–11.7) ^b	1.6 (0.5–5.0)	1.0 (0.6–1.8)	1.5 (0.9–2.7)	0.9 (0.5–1.8)	1.6 (0.5–5.0)	1.0 (0.6–1.8)	1.5 (0.9–2.7)	0.9 (0.5–1.8)
Cigarette smoking												
Never smoker	1.3 (0.5–2.0)	1.3 (0.7–1.8)	2.3 (1.4–3.2)	1.2 (0.6–1.8)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Former smoker	2.5 (0.8–4.2)	7.4 (5.0–9.7)	5.7 (4.1–7.4)	9.6 (6.9–12.3) ^b	2.8 (1.1–7.3)	8.0 (4.2–15.4)	3.2 (1.9–5.4)	13.4 (7.6–24.0)	2.8 (1.1–7.3)	8.0 (4.2–15.4)	3.2 (1.9–5.4)	13.4 (7.6–24.0)
Current smoker	9.8 (6.9–12.6)	21.2 (17.0–25.4)	31.4 (26.5–36.3)	36.5 (30.6–42.4) ^b	10.5 (4.9–22.5)	26.5 (14.9–46.9)	21.3 (13.0–35.0)	73.1 (42.7–124.9)	10.5 (4.9–22.5)	26.5 (14.9–46.9)	21.3 (13.0–35.0)	73.1 (42.7–124.9)

Statistically significant odds ratios are noted in bold. CI = confidence interval; AOR = adjusted odds ratio; NA = not applicable; NH = non-Hispanic

^aOdds ratios obtained using binary logistic regression model adjusted for all covariates listed in the table

^b*p*-trend < .05 during 2010–2013

^cEstimate suppressed due to relative standard error ≥ 40%

Table 3. Past 30-Day Use of E-Cigarettes Among US Adults: HealthStyles, 2010–2011 and 2012–2013

Characteristic	% (95% CI)		AOR (95% CI) ^a	
	2010/2011 ^b	2012/2013	2010/2011	2012/2013
	<i>n</i> = 6,555	<i>n</i> = 8,173	<i>n</i> = 6,396	<i>n</i> = 3,969
Overall	1.3 (1.0–1.7)	1.9 (1.5–2.3) ^c	NA	NA
Sex				
Male	1.1 (0.6–1.5)	1.7 (1.1–2.2)	1.00	1.00
Female	1.5 (1.0–2.1)	2.2 (1.6–2.8)	1.4 (0.8–2.4)	1.8 (1.1–2.8)
Age (years)				
18–24	^d	0.9 (0.2–1.7)	1.00	1.00
25–44	1.3 (0.7–1.9)	2.1 (1.3–2.8)	1.3 (0.5–3.4)	1.0 (0.4–2.8)
45–64	1.8 (1.1–2.5)	2.3 (1.6–3.0)	1.3 (0.5–3.5)	0.9 (0.4–2.4)
≥65	^d	1.6 (0.7–2.6)	0.6 (0.1–2.1)	0.9 (0.3–2.6)
Race/ethnicity				
White, NH	1.5 (1.0–1.9)	2.2 (1.7–2.7) ^c	1.00	1.00
Black, NH	^d	1.9 (0.6–3.2)	0.6 (0.3–1.7)	0.6 (0.3–1.3)
Other, NH	^d	^d	0.8 (0.2–2.6)	1.1 (0.4–2.7)
Hispanic	^d	^d	0.7 (0.2–2.1)	0.3 (0.1–0.9)
Education				
<High school	1.8 (0.5–3.1)	3.7 (1.8–5.5)	1.00	1.00
High school	1.8 (1.0–2.6)	1.8 (1.1–2.5)	1.2 (0.5–2.8)	0.5 (0.2–0.9)
Some college	1.4 (0.8–1.9)	1.9 (1.2–2.6)	1.1 (0.4–2.6)	0.7 (0.3–1.3)
College degree	0.5 (0.1–0.9)	1.3 (0.8–1.9) ^c	0.7 (0.2–2.0)	0.8 (0.4–1.7)
Household income				
<\$15,000	2.0 (0.7–3.4)	3.1 (1.1–5.1)	1.00	1.00
\$15,000–\$24,999	1.6 (0.5–2.7)	2.0 (0.4–3.5)	0.9 (0.3–2.2)	1.0 (0.3–2.8)
\$25,000–\$39,999	1.8 (0.7–2.9)	3.0 (1.7–4.3)	1.2 (0.5–2.9)	2.3 (1.0–5.2)
\$40,000–\$59,999	1.1 (0.2–2.0)	1.9 (1.0–2.8)	0.9 (0.3–2.3)	1.5 (0.7–3.5)
≥\$60,000	1.0 (0.5–1.4)	1.4 (0.9–1.9)	1.0 (0.5–2.3)	1.6 (0.7–3.4)
US region				
Northeast	1.4 (0.4–2.4)	1.3 (0.6–2.1)	1.00	1.00
Midwest	1.6 (0.8–2.4)	1.9 (1.0–2.9)	0.9 (0.4–2.3)	1.0 (0.5–2.3)
South	1.2 (0.6–1.7)	2.3 (1.5–3.0) ^c	0.7 (0.3–1.8)	1.4 (0.7–2.9)
West	1.2 (0.6–1.8)	1.8 (1.1–2.5)	0.8 (0.3–2.1)	1.6 (0.7–3.5)
Cigarette smoking				
Never smoker	0.2 (0.0–0.3)	^d	1.00	1.00
Former smoker	1.0 (0.3–1.7)	1.3 (0.7–1.9)	5.7 (1.9–16.9)	6.4 (2.5–16.4)
Current smoker	4.9 (3.4–6.4)	9.4 (7.1–11.6) ^c	25.8 (10.0–66.9)	54.7 (23.5–127.5)

Statistically significant odds ratios are noted in bold. CI = confidence interval; AOR = adjusted odds ratio; NA = not applicable; NH = non-Hispanic

^aOdds ratios obtained using binary logistic regression model adjusted for all covariates listed in the table

^bData were aggregated for 2010/2011 and 2012/2013 due to limited sample size. Overall prevalence of past 30 day use was 1.0% in 2010, 1.5% in 2011, 1.3% in 2012, and 2.6% in 2013.

^c $p < .05$ using chi-squared test comparing 2010/2011 vs. 2012/2013

^dEstimate suppressed due to relative standard error $\geq 40\%$

(1.3% vs. 0.5%), those living in the South (2.3% vs. 1.2%), and current cigarette smokers (9.4% vs. 4.9%) ($p < .05$). By year, current e-cigarette use was 1.0% (95% CI = 0.5–1.4) in 2010, 1.5% (95% CI = 1.0–2.0) in 2011, 1.3% (95% CI = 0.8–1.7) in 2012, and 2.6% (95% CI = 1.9–3.3) in 2013 (data not shown).

By smoking status, current e-cigarette use was 4.9% among current cigarette smokers during 2010/2011 and 9.4% during 2012/2013 (Table 3). Among current e-cigarette users, the proportion of current cigarette smokers was 72.0% during 2010/2011 and 76.8% during 2012/2013 (data not shown).

Following multivariate adjustment, females had greater odds of current use than males during 2012/2013 (OR = 1.8; 95% CI = 1.1–2.8). By race/ethnicity, Hispanics had lower odds than non-Hispanic Whites during 2012/2013 (OR = 0.3; 95% CI = 0.1–0.9). By education, those with a high school diploma had lower odds than those with

less than a high school education during 2012/2013 (OR = 0.5; 95% CI = 0.2–0.9). No significant variations in current use were observed by age, income, or region in any year. By cigarette smoking status, former smokers had greater odds than never smokers in 2010/2011 (OR = 5.7; 95% CI = 1.9–16.9) and 2012/2013 (OR = 6.4; 95% CI = 2.5–16.4). Current cigarette smokers had greater odds than never smokers during 2010/2011 (OR = 25.8; 95% CI = 10.0–66.9) and 2012/2013 (OR = 54.7; 95% CI = 23.5–127.5).

Discussion

The findings from this study reveal that awareness and use of e-cigarettes doubled among US adults during 2010–2013. In 2013, approximately 8 in 10 adults were aware of e-cigarettes, while nearly 1 in 10, or 20.4 million individuals, had ever tried these

products. Awareness increased among all sociodemographic subpopulations during 2010–2013, while ever use increased among every subpopulation except those aged 18–24 years, Hispanics, those living in the Midwest, and former smokers. The use of e-cigarettes was particularly prominent among current cigarette smokers, with over one-third (36.5%) reporting that they had ever used the product in 2013. Among adults who had smoked cigarettes in the past 30 days in 2012/2013, 9.4%, or approximately 4 million individuals, had also used e-cigarettes during the same period. Given the uncertain public health impact of ENDS, these findings underscore the importance of continued surveillance of utilization patterns to inform effective public health planning, policy, and practice.

The marked increase in awareness and use of e-cigarettes across most population subgroups is likely due in part to increased advertising of these products; during 2011–2012 alone, advertising expenditures for e-cigarettes in the US increased nearly three-fold, from \$6.4 million to \$18.3 million.²¹ In particular, e-cigarettes have been heavily marketed via television,²¹ which is the most commonly viewed media channel among youth and adults, as well as a media in which conventional tobacco advertising has been banned in the United States since 1971.²⁵ Among the more than 80 e-cigarette brands advertised during 2011–2012, expenditures were greatest for Blu and NJOY, which were promoted using national cable television advertisement buys and correspondingly dominated the e-cigarette market share during this period.^{21,26} Although increases in e-cigarette awareness were observed across all subpopulations in this study, product use did not change among certain groups such as young adults and those in the Midwest; however, it is important to note that prevalence was particularly high among these groups across years. Additionally, no change in ever use of e-cigarettes was observed among never cigarette smokers, who had lower prevalence of use compared to both former and current cigarette smokers in every survey year; increases in ever use were primarily driven by current and former smokers, which is consistent with research showing that many smokers perceive e-cigarettes to be smoking cessation aids.²⁷ In 2013, an estimated 36.5% of current smokers (15.8 million adults), 9.6% of former smokers (4.9 million adults), and 1.2% of never smokers (1.7 million adults) reported ever using e-cigarettes. The marked increase among former smokers could be attributable to the use of e-cigarettes for cessation; conversely, the increase could be attributable to new initiation of e-cigarettes among individuals who had successfully quit without previous use of the product, highlighting concerns over the potential for these products to promote relapse to combustible tobacco use.¹⁷

Consistent with previous reports of e-cigarette use among adults,^{19,22–24} variations in awareness and use of e-cigarettes were observed across population groups. Across all years, the odds of awareness were lower among non-Hispanic Blacks compared to non-Hispanic Whites, and higher among current and former cigarette smokers compared to never cigarette smokers. This finding may be due, in part, to the media by which ENDS have been marketed in recent years. Research suggests that non-Hispanic Blacks are less likely than non-Hispanic Whites to use the Internet,²⁸ which is a major source of ENDS advertising.²¹ The odds of e-cigarette use were also higher among females in more recent survey years, which may be attributable to the glamorization of e-cigarettes in print and television ads targeted toward women.²⁹ Additionally, awareness and use were greater among current and former smokers than never smokers. This finding may be due to the promotion of these

products as an alternative to conventional combusted tobacco products, particularly in situations where it is legally or socially unacceptable to smoke.²⁹ Research has shown that tobacco advertising can influence consumers' brand preferences, product initiation, and consumption.³⁰

The impact of ENDS on individual and population health remains uncertain.³¹ Some studies have found that smokers perceive these products to be smoking cessation aids,²⁷ might alleviate smoking desire after abstinence,³² and may prevent relapse among former smokers, as well as reduce cigarette consumption and facilitate cessation among current smokers.^{11,13,14} Most recently, a cross-sectional study conducted repeatedly in the United Kingdom found that adults who used e-cigarettes for the purpose of quitting smoking had higher abstinence rates than adults using nicotine replacement therapy or quitting without assistance.¹⁰ However, in the United States, ENDS are presently unregulated, produced by numerous manufacturers,²¹ and there is no conclusive scientific evidence that use of the product promotes long-term cessation.^{9,12,15} Additional concerns include the potential for these products to promote progression to combusted tobacco use among non-tobacco users, long-term dual use among current smokers, and relapse of smoking among former smokers.¹⁷ Long-term dual use among current smokers is of particular concern because only cutting down on the number of cigarettes smoked does not significantly reduce tobacco-related health risks.^{17,33,34} Additionally, harmful or potentially harmful constituents have been documented in some ENDS, although at lower levels than in cigarettes.^{3,35} Most ENDS also contain nicotine.³⁶ Although nicotine exposure in the absence of combustion is less hazardous than exposure to combusted conventional tobacco products,^{17,37} nicotine is not without risk; nicotine is addictive and exposure can have adverse effects on reproductive health and adolescent brain development.¹⁷ The situation is compounded by the fact that major tobacco companies, some of which are adjudicated racketeers,³⁸ are acquiring e-cigarette brands.³⁹ Accordingly, further research is warranted on the long-term impact of ENDS use on individual and population health, including interactions with the time, manner, and place in which these products are marketed.

The observed increase in e-cigarettes use in this study could also have health implications for non-users. Preliminary evidence suggests that ENDS may adversely impact the health of bystanders and could complicate smoke-free policy compliance. More specifically, the aerosol emitted by ENDS contains nicotine and can contain additional toxins.³⁵ Therefore, air containing ENDS aerosol is less safe than clean air, and ENDS use has the potential to involuntarily expose children and adolescents, pregnant women, and non-users to aerosolized nicotine and, if the products are altered, to other psychoactive substances.¹⁷ Additionally, the use of ENDS in public areas in which cigarette smoking is prohibited could counter the effectiveness of these policies by complicating enforcement and giving the appearance that smoking is acceptable.² Smoke-free laws increase the social unacceptability of smoking and enhance quit intentions and behaviors.⁴⁰ Some states and localities have enacted laws restricting ENDS use in public places, frequently including the products in existing comprehensive smoke-free laws; however, other jurisdictions have exempted ENDS from these laws.⁴¹

This study is subject to at least five limitations. First, *HealthStyles* is not a population-based probability survey. Research suggests that random-digit-dial and internet panel probability samples may have greater generalizability than nonprobability internet samples.⁴² However, *HealthStyles* data were weighted to be nationally

representative and tobacco use estimates from *Styles* have previously been found to be consistent with other national household surveys of US adults.²⁴ Second, small sample sizes for certain subpopulations resulted in wide confidence intervals, and in some cases, less precise estimates that could not be presented or had to be combined (e.g., current e-cigarette use) to provide statistically stable estimates. Third, the *HealthStyles* questionnaire only assessed “e-cigarettes” and may not have captured alternate types of ENDS known by different nomenclature, including e-hookahs, hookah pens, vape pens, e-cigars, and e-pipes.⁴³ Additionally, the questions used to assess e-cigarette use did not distinguish between daily and occasional use, and thus, it was not possible to assess patterns of behavioral change over time, such as experimentation or established use of e-cigarettes across categories of cigarette smoking status. Fourth, survey responses were self-reported, which could lead to reporting bias; although previous research has confirmed the validity of self-reported smoking,⁴⁴ the accuracy of self-reported ENDS use is uncertain. Finally, the survey was cross-sectional, and thus, it was not possible to assess the sequence of e-cigarette use relative to conventional cigarette smoking.

In conclusion, the findings from this study reveal that awareness and use of e-cigarettes increased considerably among US adults during 2010–2013, with over one-third of current cigarette smokers reporting they had ever used e-cigarettes in 2013. Given that ENDS have a range of potential impacts on individual and population health, and significant questions remain regarding their safety and impact on patterns of conventional tobacco use, appropriate public health surveillance of these products is warranted. In addition to continued monitoring of awareness and use of ENDS, surveillance of key indicators is critical, including impact of these products on initiation, relapse, cessation, and concurrent use with conventional tobacco products, as well as potential adverse effects on users’ and bystanders’ health and smoke-free policy compliance.

Declaration of Interests

None declared.

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