Trends In *Electronic Cigarette Use* Among U.S. Adults

Robert C. McMillen, PhD[1,2]; Mark A. Gottlieb, JD[1,3]; Regina M. Whitmore Shaefer, MPH[1]; Jonathan P. Winickoff, MD, MPH[1,3]; Jonathan D. Klein, MD, MPH[1]

([1]) Richmond Center, American Academy of Pediatrics, Elk Grove Village, IL; ([2]) Social Science Research Center, Mississippi State University, Starkville, MS; ([3]) Northeastern School of Law, Boston, MA; ([4]) MGH Center for Child and Adolescent Health Policy, Boston, MA

ABSTRACT

Objectives: We assessed trends in use of electronic cigarettes among U.S. adults, demographic predictors of use, and smoking status of current electronic cigarette users.

Methods: Mixed-mode surveys were used to obtain representative, cross-sectional samples of U.S. adults in each of five years.

Results: Sample sizes for 2010, 2011, 2012, 2013, and 2014 were 3240, 3097, 3101, 3245, and 3,030 respectively. Ever use of electronic cigarettes increased from 1.8% (2010) to 17.4% (2014), while current use increased from 0.3% to 6.8% in 2013, p<.001. Current use did not increase significantly increase from 2013 to 2014. In 2014, current use among young adults 18-24 (12.5%) and 25-44 (10.5%) was higher than adults 45-64 (5.2%), and 65+ (1.5%). Daily smokers (31.9%) and nondaily smokers (34.3%) were the most likely to currently use e-cigarettes, compared to former smokers (5.9%) and never smokers (2.3%), p<.001. However, 39.4% of current electronic cigarette users are never or former smokers.

Conclusions: There has been rapid growth in ever and current electronic cigarette use from 2010 to 2013, and a modest, nonsignificant increase over the past year. Use is highest among young adults and current cigarette smokers. Although smokers are most likely to use these products, more than a third of current users are non-smokers, suggesting that unlike tobacco harm reduction products, e-cigarettes contribute to primary nicotine addiction and to renormalization of smoking behaviors. Regulatory action is needed at the federal, state, and local levels to ensure that these products do not contribute to preventable chronic disease.

INTRODUCTION

Electronic cigarettes entered the U.S. market in 2007, and the affordability, availability, and marketing of these products has increased over the recent years. The FDA attempted and failed to regulate these products as drug delivery devices, and thus subject them to the stringent "safe and effective" standard required for drug approvals. The courts ruled that the FDA would have to regulate electronic cigarettes as a tobacco product rather than as a drug (unless the manufacturers made therapeutic claims). The FDA announced its intention to regulate electronic cigarettes as tobacco products in April of 2011 under its authority provided by the Tobacco Control Act and implemented an electronic cigarette deeming rule in April of 2014. This deeming rule, however, did not address marketing restrictions, flavors, or child-safety measures.

Although the electronic cigarette manufacturers will now have to disclose ingredients to the FDA, the Consumer Product Safety Commission does not oversee the safety and manufacturing of these products. Moreover, federal law has prohibited tobacco advertisements on television and radio since 1972, these venues are now home to advertisements for electronic cigarettes. These products do not meet many states' definition of tobacco products, and thus tobacco taxation rates do not apply in these states. Also, many state and local smokefree laws predate the development of electronic cigarettes, and thus the use of electronic cigarettes is permissible in places in which combustible tobacco products are prohibited.

In the absence of sufficient data and FDA regulation on marketing and flavors, the public health community needs more research on the prevalence of electronic cigarette use and the characteristics of people who use these products. Concerns about electronic cigarettes involve unknown characteristics of the product, health effects for users and nonusers exposed to the vapor, impact of use on cigarette smoking behaviors, lack of evidence that these products increase efficacy in cigarette smoking cessation, and lack of any product regulation. Specifically, many electronic cigarettes have unknown levels of nicotine, unknown ingredients, technical flaws, and variable quality.

To date, the growing research on the social penetration of electronic cigarettes indicates annual growth in both awareness and use of electronic cigarettes. A recent CDC study found substantial increases in past 30 day use of electronic cigarettes among both U.S. middle and high school students from 2011 to 2014. Our recent study in Nicotine and Tobacco Research found that past 30 day use of these products among U.S. adults increased from 0.3% in 2010 to 6.8%.

In summary, use of electronic cigarettes has increased substantially over the past several years, and there is a variability in use prevalence across subpopulations. Although use is substantially higher among smokers than nonsmokers, several studies have found nontrivial levels of use among nonsmokers. The purpose of this study is to assess trends in use of electronic cigarettes among U.S. adults, demographic predictors of use, and smoking status of current electronic cigarette users. Results from this study can inform regulatory decisions about these products, while the identification of potential high risk demographic groups can guide clinical counseling efforts regarding the risks of any tobacco or nicotine use.

METHODS

Cross-sectional dual-frame surveys representing national probability samples of adults were administered in 2010, 2011, 2012, 2013, and 2014. The design included a Random Digit Dialing (RDD) frame and an internet panel frame developed from a probability sample of U.S. adults, in order to reduce non-coverage issues arising from wireless substitution. Data were weighted to adjust for age, race, sex, and region, as well as frame overlap among internet panel respondents who also had a landline.

Self-Reported Use of Electronic Cigarettes

Respondents were asked "The next questions are about **electronic cigarettes, also known as e-cigarettes, vaping devices, or hookah pens.** E-cigarettes look like regular cigarettes, but are battery-powered and produce vapor instead of smoke.

Have you ever heard of an e-cigarette before this survey?" Respondents who had heard of electronic cigarettes were asked, "Have you ever used an e-cigarette, even one or two times?" Those who reported yes were asked "How often do you now vape or use e-cigarettes? Every day, some days, or not at all". Respondents who reported using these products every day or some days were considered to be current e-cigarette users.

Self-Reported Smoking

Respondents were asked, "Have you smoked at least 100 cigarettes in your entire life?" Respondents who reported that they had were then asked, "Do you now smoke cigarettes every day, some days, or not at all?" Respondents who reported that they have smoked at least 100 cigarettes and now smoke every day or some days were categorized as current smokers, while those who reported not at all were categorized as former smokers. Former smokers were asked, "About how long has it been since you last smoked cigarettes regularly?" In analyses of electronic cigarette use among never and former smokers, former smokers who had quit smoking less than five years ago were considered to be recent former smokers and those who had quit more than five years ago (and before electronic cigarettes became commonly available in the U.S. market) were considered to distant former smokers.

Analyses

Data for overall and subpopulation ever and current use of electronic cigarettes were examined to assess three year trends from 2010 to 2014. Using 2014 data, we examined demographic factors associated with electronic cigarette with multivariable logistic regression and examined nonsmokers' contribution to the electronic cigarette market.

TABLE 1. WEIGHTED SAMPLE CHARACTERISTICS

	2010 Unweighted N=3,240	2011 Unweighted N=3,097	2012 Unweighted N=3,101	2013 Unweighted N=3,245	2014 Unweighted N=3,030
Smoking Status					
Never Smokers	56.9%	56.9%	59.6%	59.9%	60.9%
Former Smokers	24.8%	25.0%	24.8%	24.6%	25.6%
Non-daily Smokers	4.6%	3.4%	3.8%	4.3%	3.5%
Daily Smokers	13.7%	14.7%	11.8%	10.1%	10.0%
Region					
Northeast	12.6%	12.9%	17.8%	17.3%	18.3%
Midwest	18.4%	18.9%	21.7%	22.1%	21.4%
South	37.6%	37.2%	37.5%	37.8%	36.9%
West	31.4%	31.0%	23.0%	22.7%	23.4%
Race					
White	74.2%	69.5%	71.5%	70.3%	67.5%
Black	11.5%	11.3%	11.4%	11.3%	11.9%
Other	14.3%	19.2%	17.1%	17.5%	20.7%
Age					
18-24	13.7%	9.3%	11.4%	10.7%	12.5%
25-44	38.8%	39.7%	38.3%	37.3%	35.0%
45-64	33.3%	34.9%	34.7%	34.3%	34.7%
65+	14.2%	16.1%	15.6%	16.2%	17.8%
Sex					
Males	47.6%	48.3%	48.1%	47.4%	48.3%
Females	52.4%	51.7%	51.9%	52.6%	51.7%
Education					
Less than HS	9.3%	10.5%	9.9%	9.0%	12.4%
High School	28.5%	27.3%	28.8%	26.9%	29.5%
Some College	29.3%	29.6%	28.1%	28.9%	28.8%
College Degree	33.0%	32.6%	33.4%	34.9%	29.2%

TABLE 2. PREVALENCE OF ELECTRONIC CIGARETTE EVER USE

	2010	2011	2012	2013	2014
Overall	1.8% (1.3%-2.3%)	7.3% (6.4%-8.2%)	10.6% (9.5%-11.7%)	13.0% (11.8%-14.2%)	17.4% (16.1%-18.7%)
Smoking Status					
Never Smokers	0.3% (0.0%-0.6%)	1.2% (0.7%-1.7%)	2.4% (1.7%-3.1%)	3.5% (2.7%-4.3%)	7.4% (6.2%-8.6%)
Former Smokers	1.5% (0.7%-2.3%)	6.5% (4.8%-8.2%)	11.7% (9.5%-13.9%)	13.5% (11.1%-15.9%)	17.6% (14.9%-20.3%)
Non-daily Smokers	8.2% (2.6%-13.8%)	13.9% (6.5%-21.3%)	27.1% (18.3%-35.9%)	47.0% (38.5%-55.5%)	62.9% (53.7%-72.1%)
Daily Smokers	6.2% (4.0%-8.4%)	30.9% (26.4%-35.4%)	44.6% (39.3%-49.9%)	54.2% (48.7%-59.7%)	62.1% (56.6%-67.6%)
Region					
Northeast	2.7% (1.4%-4.0%)	4.8% (3.0%-6.6%)	8.9% (6.5%-11.3%)	10.1% (7.5%-12.7%)	14.0% (11.1%-16.9%)
Midwest	1.4% (0.6%-2.2%)	7.8% (5.9%-9.7%)	12.9% (10.5%-15.3%)	11.6% (9.2%-14.0%)	17.7% (14.7%-20.7%)
South	1.6% (0.9%-2.3%)	7.0% (5.5%-8.5%)	10.0% (8.3%-11.7%)	14.9% (12.9%-16.9%)	18.1% (15.8%-20.4%)
West	1.9% (0.8%-3.0%)	8.2% (6.1%-10.3%)	10.6% (8.2%-13.0%)	14.1% (11.5%-16.7%)	19.1% (16.2%-22.0%)
Race					
White	1.7% (1.2%-2.2%)	8.3% (7.2%-9.4%)	12.3% (11.0%-13.6%)	13.1% (11.7%-14.5%)	18.2% (16.5%-19.9%)
Black	1.9% (0.3%-3.5%)	3.7% (1.7%-5.7%)	5.3% (2.8%-7.8%)	11.5% (8.1%-14.9%)	14.0% (10.4%-17.6%)
Other	1.8% (0.4%-3.2%)	5.6% (3.4%-7.8%)	7.3% (4.7%-9.9%)	14.0% (11.1%-16.9%)	16.7% (13.7%-19.7%)
Age					
18-24	2.5% (0.6%-4.4%)	7.3% (4.5%-10.1%)	15.0% (9.9%-20.1%)	21.0% (16.6%-25.4%)	24.7% (29.8%-39.6%)
25-44	2.1% (1.2%-3.0%)	10.7% (8.6%-12.8%)	13.9% (11.6%-16.2%)	15.7% (13.6%-17.8%)	21.9% (19.4%-24.4%)
45-64	1.6% (0.9%-2.3%)	4.9% (3.6%-6.2%)	8.6% (7.9%-11.3%)	12.2% (10.2%-14.2%)	13.7% (11.6%-15.8%)
65 +	0.4% (0.0%-0.9%)	4.4% (3.1%-5.7%)	2.3% (1.3%-3.3%)	4.8% (2.9%-6.7%)	4.7% (2.9%-6.5%)
Sex					
Males	2.2% (1.4%-3.0%)	8.8% (7.3%-10.3%)	11.1% (9.4%-12.8%)	13.9% (12.1%-15.7%)	20.0% (17.9%-22.1%)
Females	1.4% (0.9%-1.9%)	5.8% (4.7%-6.9%)	10.1% (8.7%-11.5%)	12.4% (10.8%-14.0%)	15.1% (13.3%-16.9%)
Education					
Less than HS	0.7% (0.0%-1.7%)	11.6% (7.8%-15.4%)	8.5% (5.2%-11.8%)	16.9% (12.4%-21.4%)	27.8% (23.2%-32.4%)
High School	1.7% (0.9%-2.5%)	7.5% (5.8%-9.2%)	14.0% (11.7%-16.3%)	16.9% (12.5%-17.3%)	21.4% (18.7%-24.1%)
Some College	3.7% (2.4%-5.0%)	8.3% (6.5%-10.1%)	13.9% (11.6%-16.2%)	18.9% (16.3%-21.5%)	27.0% (24.1%-29.9%)
College Degree	0.5% (0.1%-0.9%)	4.8% (3.5%-6.1%)	5.6% (4.3%-6.9%)	6.2% (4.8%-7.6%)	9.5% (7.6%-11.4%)

TABLE 3. PREVALENCE OF ELECTRONIC CIGARETTE CURRENT USE

	2010	2011	2012	2013	2014
Overall	0.3% (0.1%-0.5%)	0.8% (0.5%-1.1%)	2.6% (2.0%-3.2%)	6.8% (5.9%-7.7%)	7.3% (6.4%-8.2%)
Smoking Status					
Never Smokers	0.1% (0.0%-0.2%)	0.1% (0.0%-0.2%)	0.1% (0.0%-0.2%)	1.4% (0.9%-1.9%)	2.3% (1.6%-3.0%)
Former Smokers	0.3% (0.0%-0.7%)	0.1% (0.0%-0.3%)	1.1% (0.4%-1.8%)	5.4% (3.8%-7.0%)	5.9% (4.2%-7.6%)
Non-daily Smokers	1.4% (0.0%-3.3%)	1.0% (0.0%-2.9%)	3.1% (0.6%-5.5%)	34.1% (26.0%-42.2%)	34.3% (23.2%-43.4%)
Daily Smokers	1.4% (0.3%-2.5%)	5.0% (2.0%-7.0%)	10.8% (7.5%-14.1%)	30.3% (25.2%-35.4%)	31.9% (26.6%-37.2%)
Region					
Northeast	0.5% (0.0%-1.2%)	0.3% (0.0%-0.8%)	1.5% (0.5%-2.5%)	5.5% (3.6%-7.4%)	5.9% (3.9%-7.9%)
Midwest	0.3% (0.0%-0.7%)	0.5% (0.0%-1.1%)	2.3% (1.2%-3.4%)	6.3% (4.5%-8.1%)	7.0% (5.0%-9.0%)
South	0.2% (0.0%-0.5%)	0.4% (0.0%-0.8%)	1.4% (0.7%-2.1%)	8.3% (6.7%-9.9%)	8.0% (6.4%-9.6%)
West	0.3% (0.0%-0.6%)	1.7% (0.9%-2.5%)	2.0% (0.9%-3.1%)	6.0% (4.2%-7.8%)	7.8% (5.8%-9.8%)
Race					
White	0.3% (0.1%-0.5%)	0.8% (0.4%-1.2%)	1.9% (1.4%-2.4%)	6.7% (5.6%-7.8%)	8.0% (6.8%-9.2%)
Black	0.3% (0.0%-0.9%)	0.6% (0.0%-1.4%)	0.3% (0.0%-0.9%)	4.3% (2.1%-6.4%)	5.7% (3.3%-8.1%)
Other	0.4% (0.0%-1.0%)	1.0% (0.2%-1.8%)	2.1% (0.7%-3.5%)	8.9% (6.5%-11.3%)	5.3% (3.5%-7.1%)
Age					
18-24	0.0% (0.0%-0.0%)	0.0% (0.0%-0.0%)	3.4% (0.8%-6.0%)	14.2% (10.4%-18.0%)	12.5% (9.1%-15.9%)
25-44	0.4% (0.0%-0.8%)	1.3% (0.6%-2.0%)	3.7% (2.8%-4.6%)	8.6% (7.0%-10.2%)	10.5% (8.6%-12.4%)
45-64	0.6% (0.1%-1.1%)	0.3% (0.1%-0.9%)	1.9% (1.1%-2.7%)	5.5% (4.1%-6.9%)	5.2% (3.8%-6.6%)
65 +	0.0% (0.0%-0.0%)	0.4% (0.0%-1.0%)	0.7% (0.1%-1.3%)	1.2% (0.2%-2.2%)	1.5% (0.5%-2.5%)
Sex					
Males	0.2% (0.0%-0.4%)	1.2% (0.6%-1.8%)	1.8% (1.1%-2.5%)	7.1% (5.8%-8.4%)	8.9% (7.4%-10.4%)
Females	0.5% (0.2%-0.8%)	0.4% (0.1%-0.7%)	3.3% (2.1%-4.5%)	6.6% (5.4%-7.8%)	5.7% (4.5%-6.9%)
Education					
Less than HS	0.3% (0.0%-0.9%)	1.9% (0.4%-3.4%)	0.8% (0.0%-1.9%)	10.7% (7.0%-14.4%)	16.8% (13.0%-20.6%)
High School	0.4% (0.0%-0.8%)	0.4% (0.0%-0.8%)	1.3% (0.5%-2.1%)	7.7% (5.9%-9.5%)	7.3% (5.6%-9.0%)
Some College	0.4% (0.0%-0.8%)	0.7% (0.2%-1.2%)	3.3% (2.1%-4.5%)	8.6% (7.0%-12.6%)	7.6% (5.8%-9.4%)
College Degree	0.2% (0.0%-0.5%)	0.9% (0.3%-1.5%)	1.0% (0.4%-1.6%)	2.2% (1.3%-3.1%)	3.0% (1.9%-4.1%)

TABLE 4. LOGISTIC REGRESSION, PREVALENCE OF ELECTRONIC CIGARETTE USE, 2014

	Ever Use Overall N=2,915	Current Use Overall N=2,912
Smoking Status		
Never Smokers	REF	REF
Former Smokers	5.9 (4.3-8.1)	4.1 (2.6-6.6)
Non-daily Smokers	40.9 (24.3-69.0)	27.3 (15.3-48.7)
Daily Smokers	38.3 (26.4-55.6)	20.7 (13.2-32.6)
Region		
Northeast	REF	REF
Midwest	1.4 (1.02-1)	1.1 (0.7-1.9)
South	1.3 (0.9-1.9)	1.1 (0.7-1.9)
West	1.4 (1.02-1)	1.2 (0.7-2.0)
Race		
White	2.4 (1.6-3.6)	2.3 (1.3-4.1)
Black	REF	REF
Other	1.9 (1.2-3.0)	1.4 (0.7-2.7)
Age		
18-24	37.0 (21.2-64.4)	15.4 (6.7-35.6)
25-44	8.8 (5.4-14.3)	8.1 (3.8-17.4)
45-64	3.1 (1.9-5.0)	2.9 (1.3-6.4)
65+	REF	REF
Sex		
Males	1.2 (0.9-1.5)	1.3 (0.9-1.8)
Females	REF	REF
Education		
Less than HS	1.5 (1.0-2.3)	3.3 (1.9-5.7)
High School	1.6 (1.1-2.3)	1.6 (0.9-2.7)
Some College	1.2 (0.8-1.7)	1.9 (1.1-3.1)
College Degree	REF	REF

RESULTS

Trends

In weighted analysis, ever use of electronic cigarettes increased from 1.8% to 17.4% (see Table 2). Among subpopulations, ever use also increased significantly across all assessed groups over the four year period (p<.05 for all comparisons). Current use also demonstrated substantial growth from 2010 (0.3%) to 2013 (6.8%); however there was only a modest, nonsignificant increase over the past year.

Ever and Current Electronic Cigarette Use, 2014

Daily smokers (62.1%) and nondaily smokers (62.9%) were the most likely to have tried electronic cigarettes. However, a nontrivial amount of nonsmokers had also tried these products, former smokers (17.6%) and never smokers (7.4%) (see Table 2). Approximately 4 of ten adults who have tried electronic cigarettes report current use (see Table 3). In multivariable analysis, current daily, nondaily, and former smoking status remained significant predictors of ever and current use, as did race, age, and education. White adults were more likely than black adults, younger adults were more likely than older adults, and adults with some college education were more likely than adults with a college degree to have tried or currently use electronic cigarettes (see Table 4).

Current Use among Nonsmokers

Despite our finding that current use prevalence is substantially higher among current smokers than adults who have never smoked cigarettes or who have successfully quit smoking cigarettes, more than a third of current electronic cigarette users are either never smokers (18.9%) or former smokers (20.7%). However, it is possible that some former smokers used these products as a form of nicotine replacement therapy to help them quit. To address this possibility, we examined use among only never smokers and former smokers who quit more than 6 years ago (distant former smokers). Note that electronic cigarettes were not available on the U.S. market prior to 2007. After removing recent former smokers from our analyses, we found that more than 20 percent of current electronic cigarette users are never smokers (18.9%) or distant former smokers (2.8%).

DISCUSSION

Our study demonstrated rapid growth in electronic cigarette use among U.S. adults from 2010 to 2013, and a nonsignificant increase in current use from 2013 to 2014. Although the magnitude varied across demographic groups, we observed statistically significant increases from 2010 to 2014 across all levels of smoking status, region, race, age, sex, and education. Consistent with previous research, we found the use of electronic cigarettes varied by cigarette smoking status. Current smokers were more likely than never and former smokers to have tried electronic cigarettes.

Although smokers are most likely to use these products, more than a third of current users are non-smokers, suggesting that unlike tobacco harm reduction products, e-cigarettes can contribute to primary nicotine addiction and to renormalization of smoking behaviors. Consideration of potential harm reduction benefits of e-cigarettes should be balanced against this finding. Although the scientific evidence has not yet resolved the issue of whether e-cigarettes help adult smokers to quit cigarettes, there is no public health benefit for nonsmokers initiating and maintaining e-cigarettes use. Regulatory action is needed at the federal, state, and local levels to ensure that these products do not contribute to nicotine use initiation and preventable chronic disease.

This study has at least two limitations. First, our dual frame methodology is designed to reduce the potential for sample bias associated with either RDD or internet panel samples alone, but we still can't eliminate the potential for noncoverage bias. Also, the use of the internet panel raises some concern about the representativeness of the sample. However, several studies demonstrate that this probability-based panel can produce results similar to well-designed RDD surveys and our use of this dual frame methodology produced estimates for current smoking that did not differ from those of several large, government surveys of U.S. adults. Second, the construct we used to examine the role e-cigarettes may have had in the former smokers' quit attempts is rather crude. Use by former smokers to quit smoking has different implications than use by former smokers who are reinitiating nicotine use (and possibly addiction).

In conclusion, there has been rapid growth in ever and current electronic cigarette use over the past five years, although growth in current use slowed down from 2013 to 2014. Although smokers are most likely to use these products, almost a third of current users are nonsmokers, undermining potential public health benefits cigarette smokers possibly switching to electronic cigarettes.

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