

Factors Associated with E-cigarette Use

A National Population Survey of Current and Former Smokers

Daniel P. Giovenco, MPH, M. Jane Lewis, DrPH, Cristine D. Delnevo, PhD, MPH

Background: Few national surveys document the prevalence of e-cigarette use in the U.S. The existing metric to assess current use likely identifies individuals who have recently tried an e-cigarette but do not continue to use the product.

Purpose: To document the prevalence of e-cigarette ever use, current use, and established use in a nationally representative survey of current and former cigarette smokers in the U.S.

Methods: A random sample of current and former cigarette smokers completed a web-based survey in June 2013 ($n=2,136$). Data were analyzed in November 2013. Multivariate logistic regression identified demographic and smoking-related factors associated with each use category. Point estimates with 95% CIs described e-cigarette use behaviors (e.g., preferred brand, purchasing patterns) for each group.

Results: Almost half of respondents had tried e-cigarettes (46.8%), but prevalence of established use remained low (3.8%). Although trial of e-cigarettes was highest among daily smokers, the odds of being an established e-cigarette user were greater for former smokers ($OR=3.24$, 95% $CI=1.13, 9.30$, $p<0.05$). Furthermore, e-cigarette preference and use patterns varied among ever, current, and established users. Established users reported using rechargeable e-cigarettes, having a regular brand, and using e-cigarettes at home and in the workplace at much higher levels than the “current use” metric captures.

Conclusions: Improved survey measures for e-cigarette use are needed. The identification of established e-cigarette users may provide insight to product features or other individual factors that are associated with sustained use of e-cigarettes.

(Am J Prev Med 2014;■(■):■■■-■■■) © 2014 American Journal of Preventive Medicine

Introduction

Electronic cigarettes (e-cigarettes) are battery-operated devices that deliver nicotine vapor to the user when inhaled.¹ E-cigarette sales approached \$1.8 billion in 2013, and some analysts predict that e-cigarette consumption will surpass traditional cigarettes within the next decade.² Unfortunately, few nationally representative studies document prevalence of e-cigarette use, and all define “current use” as any use in the past 30 days.³⁻⁷ Given the sharp rise in “ever use³” and the increasing pervasiveness of e-cigarettes in popular culture,⁸ the existing metric to assess current use potentially captures individuals who

have recently tried an e-cigarette but do not continue using (i.e., “recent experimenters”).

Indeed, trade publications have noted that e-cigarette trial is high among cigarette smokers, but adoption is low.⁹ To better delineate e-cigarette use patterns, the prevalence of ever use, current use, and a newly created category of “established use” were examined in a nationally representative web survey of current and former cigarette smokers. An analysis of e-cigarette behaviors identified how patterns of use vary between groups.

Methods

Participants

Eligible participants were randomly sampled from *Knowledge-Panel*, a nationally representative, online panel maintained by GfK Knowledge Networks, which has been used in other studies to estimate prevalence of e-cigarette use.^{3-5,7} Panel members are recruited using probability-based sampling from the U.S. Postal Service’s Delivery Sequence File, a sampling frame of addresses that covers approximately 97% of U.S. households. Thus,

From the Center for Tobacco Studies, Rutgers School of Public Health, Rutgers University, New Brunswick, New Jersey

Address correspondence to: Daniel P. Giovenco, MPH, Center for Tobacco Studies, Rutgers School of Public Health, 335 George Street, Suite 2100, New Brunswick NJ 08903. E-mail: d.giovenco@rutgers.edu.

0749-3797/\$36.00

<http://dx.doi.org/10.1016/j.amepre.2014.04.009>

KnowledgePanel is not susceptible to non-probability sampling errors—a notable criticism of “opt-in” web-based panels.¹⁰ The company’s recruitment and statistical weighting methods are described elsewhere in greater detail.^{11,12} In total, 2,136 current and former cigarette smokers who quit in the past 5 years completed the survey in June 2013. Data were analyzed in November 2013. The Rutgers University IRB approved the study and participants provided informed consent.

Measures

Three e-cigarette use measures were computed: (1) ever use; (2) current use; and (3) established use. Individuals who responded *yes* to the question *Have you ever tried e-cigarettes, even once?* were considered ever users. Those who reported a number greater than zero for the question *During the past 30 days, on how many days have you used e-cigarettes?* were considered current users. Current users who responded *more than 50 times* to the question *In your best estimate, about how many times in your life have you used e-cigarettes?* were considered established users.

These categories are not mutually exclusive; for example, established users are both current and ever users. The inclusion of a quantitative criterion for established use is consistent with cigarette smoking surveillance measures¹³ and has also been used for cigars and smokeless tobacco.¹⁴ Covariates of interest included gender, age, education, race/ethnicity, census region, and cigarette smoking status.

Current smokers were defined as having smoked 100 cigarettes in their lives and now smoking *every day* or *some days*. Former smokers have smoked 100 cigarettes in their lives, currently smoke *not at all*, and quit within the past 5 years. A new variable was created to denote whether participants lived in a high cigarette excise tax state (i.e., top 10th percentile), given that e-cigarette companies have promoted their product as a cheaper alternative to cigarettes.

To distinguish between different types of e-cigarettes, a user’s regular brand was coded as a “cigalike,” which resembles a traditional cigarette (e.g., blu, NJOY), or a “vaporizer,” which has a tank system allowing users to add their own “e-liquid.” Respondents also indicated where they normally purchase and use their e-cigarettes and whether they typically use rechargeable or disposable e-cigarettes. Only respondents who had used an e-cigarette in the past 30 days answered these detailed questions about e-cigarette use.

Statistical Analysis

Analyses were conducted using SAS, version 9.3 (SAS Institute Inc., Cary NC). All statistical tests used survey procedures to account for the complex sampling design. Sample weights were applied to the data to adjust for varying probability of selection (base weight) associated with survey recruitment. Additionally, a second stage of weighting (post-stratification) was applied to address non-response and non-coverage. Point estimates for three categories of e-cigarette use are presented with 95% CIs. Logistic regression was used to calculate AORs for ever, current, and established e-cigarette use, controlling for demographic variables, cigarette smoking status, and state cigarette excise tax. To demonstrate how patterns of use differ between groups, variables related to e-cigarette behaviors (e.g., brand preference, purchasing patterns) were presented as point estimates with 95% CIs.

Results

Among current and former smokers, the prevalence of ever, current, and established e-cigarette use was 46.8%, 16.1%, and 3.8%, respectively (Table 1). Factors associated with ever use differed from those associated with established use, with the exception of race/ethnicity. Whites were more likely than non-whites to report e-cigarette use for both categories. Younger age and high cigarette tax were associated with higher odds of ever use, but these relationships disappeared for current and established use.

Although daily smokers were significantly more likely to report ever use than some day and former smokers, this pattern reversed for established use, with former smokers being 3.24 times more likely (95% CI=1.13, 9.30, $p < 0.05$) than daily smokers to be established users. Gender, educational attainment, and geographic region were not significantly associated with e-cigarette use across all categories.

Behaviors and patterns of e-cigarette use among established users are considerably underestimated when they are categorized with all current users. Table 2 indicates that established users report having a regular brand of e-cigarettes (77.3%), using rechargeable e-cigarettes (84.7%), and using e-cigarettes at home and work (94.6% and 66.6%) at much higher levels than the current use group to which they are traditionally assigned.

Discussion

Many of this study’s findings, like higher odds of ever use among young adults and non-Hispanic whites, are consistent with existing e-cigarette surveillance studies.^{5,15–16} This is the first study, however, to highlight patterns of e-cigarette use using a threshold to identify individuals who are not experimenters, but have likely become established users.

Factors associated with established use do not predict current use, suggesting that differences exist between established users and other individuals traditionally categorized as current users in the research literature. Considering recent increases in e-cigarette experimentation, the current use group potentially contains individuals who have only experimented with e-cigarettes in the past 30 days. Survey measures identifying established users who have adopted the product may provide insight into product features or other factors associated with sustained use of e-cigarettes.

This study was restricted to current and former cigarette smokers, and the sample size of established e-cigarette users was small. Both of these limitations may hinder the generalizability of the findings. Additionally, the threshold of *more than 50 times* to categorize respondents as

Table 1. Point estimates and AORs for three e-cigarette use categories, n=2,136

	Ever use ^a		Current use ^b		Established use ^c	
	Weighted %	AOR	Weighted %	AOR	Weighted %	AOR
Gender						
Male (ref)	45.1 (40.6, 49.5)	1.00	14.5 (11.5, 17.5)	1.00	4.5 (2.5, 6.4)	1.00
Female	48.7 (44.3, 53.0)	1.15 (0.89, 1.49)	17.7 (14.2, 21.2)	1.29 (0.92, 1.81)	3.1 (1.5, 4.7)	0.77 (0.38, 1.58)
Age group (years)						
18–29	57.8 (49.1, 66.5)	2.32 (1.49, 3.63)***	18.9 (12.2, 25.6)	1.63 (0.95, 2.79)	3.8 (0.3, 7.4)	1.30 (0.43, 3.91)
30–44	47.5 (41.4, 53.6)	1.42 (1.01, 2.01)*	17.0 (12.5, 21.5)	1.36 (0.86, 2.17)	3.1 (0.7, 5.5)	0.96 (0.34, 2.73)
45–59	42.7 (38.3, 47.1)	1.09 (0.81, 1.47)	15.0 (11.8, 18.2)	1.18 (0.77, 1.81)	5.0 (3.0, 7.0)	1.90 (0.86, 4.20)
≥60 (ref)	40.7 (35.2, 46.3)	1.00	13.1 (9.2, 17.0)	1.00	3.0 (1.3, 4.8)	1.00
Education						
HS or less (ref)	45.7 (41.4, 50.1)	1.00	15.0 (11.9, 18.1)	1.00	3.2 (1.7, 4.8)	1.00
Some college or more	48.1 (43.6, 52.5)	1.23 (0.95, 1.58)	17.3 (13.9, 20.7)	1.25 (0.90, 1.74)	4.4 (2.4, 6.4)	1.07 (0.57, 2.02)
Race/ethnicity						
White, non-Hispanic	49.1 (45.5, 52.6)	1.42 (1.04, 1.93)*	16.7 (14.0, 19.3)	1.24 (0.81, 1.89)	4.5 (2.9, 6.1)	2.56 (1.04, 6.30)*
Non-white (ref)	40.8 (34.6, 47.1)	1.00	14.5 (9.9, 19.2)	1.00	1.9 (0.6, 3.2)	1.00
Census region						
Northeast (ref)	49.0 (41.7, 56.3)	1.00	15.1 (9.5, 20.7)	1.00	2.5 (0.4, 4.7)	1.00
Midwest	47.0 (41.1, 52.9)	1.22 (0.78, 1.89)	14.8 (11.2, 18.3)	1.25 (0.71, 2.20)	5.1 (2.8, 7.4)	3.26 (0.90, 11.83)
South	44.9 (39.8, 50.0)	1.16 (0.76, 1.78)	16.2 (12.4, 20.0)	1.43 (0.82, 2.51)	3.1 (1.1, 5.1)	2.28 (0.62, 8.36)
West	48.3 (40.9, 55.8)	1.29 (0.82, 2.02)	18.3 (12.3, 24.3)	1.58 (0.89, 2.83)	4.6 (1.0, 8.3)	3.17 (1.00, 10.06)
Cigarette smoking status						
Every day (ref)	49.6 (46.2, 53.1)	1.00	16.4 (13.9, 18.9)	1.00	2.8 (1.9, 3.8)	1.00
Some days	43.6 (37.2, 50.0)	0.70 (0.51, 0.94)*	16.4 (11.6, 21.2)	0.94 (0.63, 1.39)	3.8 (1.7, 5.9)	1.59 (0.84, 3.03)
Former	38.3 (25.7, 51.0)	0.55 (0.32, 0.94)*	13.9 (4.7, 23.1)	0.75 (0.35, 1.62)	8.3 (1.2, 15.5)	3.24 (1.13, 9.30)*
State cigarette tax						
Top 10th percentile ^d	55.9 (47.3, 64.5)	1.70 (1.07, 2.71)*	19.5 (11.6, 27.5)	1.59 (0.86, 2.94)	4.7 (1.0, 8.5)	2.19 (0.63, 7.62)
Others (ref)	45.6 (42.3, 48.9)	1.00	15.6 (13.3, 18.0)	1.00	3.7 (2.4, 5.0)	1.00
Overall prevalence	46.8 (43.7, 49.9)		16.1 (13.8, 18.4)		3.8 (2.5, 5.0)	

Note: Boldface indicates statistical significance. Values within parentheses are 95% CIs.

^aUsed an e-cigarette at least once in their lifetime

^bUsed an e-cigarette at least once in the past 30 days

^cUsed an e-cigarette at least once in the past 30 days and more than 50 times in their lifetime

^dIncludes New York, Rhode Island, Massachusetts, Connecticut, Hawaii, and Washington

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

HS, high school

Table 2. Patterns of use for three categories of e-cigarette users, weighted % (95% CI)

	Ever users (n=1,012)	Current users (n=351)	Established users (n=84)
Made past year quit attempt	56.3 (52.0, 60.5)	62.5 (55.4, 69.5)	76.5 (65.5, 87.5)
Brands tried using			
blu	41.3 (36.8, 45.8)	47.5 (39.6, 55.3)	32.0 (15.0, 49.1)
NJOY	17.6 (14.3, 21.0)	21.1 (14.7, 27.6)	24.0 (7.6, 40.5)
V2Cigs	5.6 (3.8, 7.5)	6.7 (2.9, 10.4)	10.4 (0.6, 20.1)
Green Smoke	4.7 (2.6, 6.7)	5.1 (0.7, 9.5)	3.3 (0.0, 7.3)
Logic	3.8 (2.4, 5.2)	3.7 (1.6, 5.9)	6.4 (0.3, 12.5)
Other	38.3 (33.9, 42.8)	40.9 (33.2, 48.6)	63.5 (46.9, 80.2)
Has regular brand	Not asked	42.5 (34.6, 50.4)	77.3 (66.4, 88.1)
blu		30.7 (17.8, 43.6)	16.5 (0.0, 37.0)
NJOY		9.4 (2.9, 16.0)	4.3 (0.0, 9.6)
V2Cigs		3.1 (0.6, 5.5)	4.3 (0.0, 9.0)
Other, cigalike ^a		28.9 (18.5, 39.3)	32.8 (15.4, 50.1)
Other, vaporizer ^b		19.9 (8.5, 31.2)	34.8 (12.7, 56.8)
Other, unknown ^c		8.1 (0.5, 15.7)	7.3 (0.5, 14.2)
Places they use e-cigarettes			
Home		81.4 (75.5, 87.4)	94.6 (89.6, 99.5)
Restaurants/bars		23.0 (16.4, 29.7)	33.9 (17.1, 50.6)
Driving		49.5 (41.6, 57.4)	68.1 (50.8, 85.4)
Work		35.4 (27.7, 43.1)	66.6 (53.3, 80.0)
Other		16.5 (10.2, 22.9)	17.8 (7.8, 27.9)
Type typically used			
Rechargeable		60.6 (53.4, 67.8)	84.7 (75.0, 94.5)
Disposable		28.2 (21.8, 34.5)	3.6 (0.0, 8.4)
Both		11.2 (6.5, 16.0)	11.7 (3.0, 20.4)
Places they buy e-cigarettes			
Online		24.7 (17.9, 31.5)	46.2 (29.0, 63.5)
Conv. store/gas station		36.3 (28.8, 43.9)	35.8 (17.9, 53.7)
Drug store		12.0 (7.4, 16.5)	3.3 (0.0, 8.2)
Grocery store		7.6 (2.6, 12.6)	11.0 (0.0, 26.6)
Liquor store		6.9 (2.6, 11.3)	2.9 (0.0, 6.3)
Mall kiosk		2.8 (0.6, 5.0)	3.7 (0.0, 7.9)
Tobacco store		27.3 (20.7, 33.9)	33.8 (19.8, 47.7)
Other		13.3 (7.5, 19.0)	7.5 (1.7, 13.3)

^aResemble traditional cigarettes in shape and appearance (e.g., blu, NJOY, Logic)^bVary in shape and size and often have a tank system that allows user to add "e-liquid"^c"Unknown" signifies that the respondent's brand could not be identified online.

established users reflects the upper bounds of a categorical survey item and is not based on methodologic testing.

Future research should increase the upper bound of such a survey item to allow examination of an appropriate threshold for established e-cigarette use. The “100 sticks” criterion used for cigarettes may be inappropriate for e-cigarettes owing to variation in e-cigarette unit size and volume (i.e., an e-cigarette cartridge may have more or less “puffs” than a cigarette). Despite these limitations, this study underscores the need for improved survey measures in e-cigarette surveillance studies given the product’s increasing popularity in the U.S.

The project described was supported by grant no. R21CA155956 and grant no. R21CA159160 from the National Cancer Institute.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Cancer Institute or NIH.

No financial disclosures were reported by the authors of this paper.

References

- Food and Drug Administration. Regulation of e-cigarettes. fda.gov/newsevents/publichealthfocus/ucm172906.htm.
- Hanson A. E-cigarettes: a path to the future. csnews.com/top-story-to-bacco-c4-e-cigarettes__a_path_to_the_future-64845.html.
- King BA, Alam S, Promoff G, Arrazola R, Dube SR. Awareness and ever use of electronic cigarettes among U.S. adults, 2010–2011. *Nicotine Tob Res* 2013;15(9):1623–7.
- Pearson JL, Richardson A, Niaura R, Vallone DM, Abrams DB. E-cigarette awareness, use, and harm perceptions in U.S. adults. *Am J Public Health* 2012;102(9):1758–66.
- Popova L, Ling PM. Alternative tobacco product use and smoking cessation: a national study. *Am J Public Health* 2013;103(5):923–30.
- Regan AK, Promoff G, Dube SR, Arrazola R. Electronic nicotine delivery systems: adult use and awareness of the “e-cigarette” in the USA. *Tob Control* 2013;22(1):19–23.
- Zhu S-H, Gamst A, Lee M, et al. The use and perception of electronic cigarettes and snus among the U.S. population. *PLoS One* 2013;8(10):e79332.
- Grana RA, Glanz SA, Ling PM. Electronic nicotine delivery systems in the hands of Hollywood. *Tob Control* 2011;20(6):425–6.
- Reynolds American, Inc. Transformation through innovation. Winston-Salem NC: Reynolds American, Inc., 2013. <http://files.shareholder.com/downloads/RAI/2864866953x0x707287/38bb7b2d-ab67-4192-b3e1-753b8c2223c9/Investor%20Day%202013%20Print%20PDF.pdf>.
- Baker R, Brick JM, Bates NA, et al. Summary report of the AAPOR Task Force on non-probability sampling. *J Suvery State Methodol* 2013;1(2):90–143.
- GfK Knowledge Networks. KnowledgePanel design summary. www.knowledgenetworks.com/knpanel/KNPanel-Design-Summary.html.
- GfK Knowledge Networks. Methodological papers, presentations, and articles on KnowledgePanel. www.knowledgenetworks.com/ganp/reviewer-info.html.
- CDC. Current cigarette smoking among adults—U.S., 2011. *MMWR Morb Mortal Wkly Rep* 2012;61(44):889–94.
- CDC. Tobacco use among adults—U.S., 2005. *MMWR Morb Mortal Wkly Rep* 2006;55(42):1145–8.
- Adkinson SE, O'Connor RJ, Bansal-Travers M, et al. Electronic nicotine delivery systems: international tobacco control four-country survey. *Am J Prev Med* 2013;44(3):207–15.
- Choi K, Forster J. Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young U.S. Midwestern adults. *Am J Public Health* 2013;103(3):556–61.